

Technical Memorandum

To: Tamara Cardona and Ann Farris, ADEC
From: Brian Angerman and Todd DeJournett
Subject: Air Sparge Pilot Test – Results Evaluation
Date: Revised January 18, 2013
Project: Flint Hills Resources Alaska, LLC, North Pole Refinery
File 100.38.090
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1.0 Introduction

Barr Engineering Company (Barr) has prepared this Air Sparge Pilot Test – Results Evaluation Technical Memorandum (Tech Memo) on behalf of Flint Hills Resources Alaska (FHRA) for the North Pole Refinery (NPR) site in North Pole, Alaska. This Tech Memo is provided as a summary update of the ongoing pilot test progress derived from data through November 2012. The progress results of the pilot test are being utilized to evaluate Air Sparge as a potential remedial action. This memo was originally submitted as Appendix C to the Draft Final Onsite Feasibility Study (FS) (Arcadis, May 2012) and is being revised to present and evaluate additional data that has been collected since the FS submittal.

The pilot test objectives were:

- To evaluate the sulfolane removal efficiency in groundwater using air sparge technology.
- To collect data to aid in the design and operation of a potential full-scale air sparge system.

FHRA installed an air sparge pilot system that consists of eight air sparge points, eight monitoring wells, three sparge monitoring point nests, and a structure to house treatment system components (Figure 1). A work plan and subsequent system construction were prepared in general accordance with ADEC's September 2009 *Site Characterization Work Plan and Reporting Guidance for Investigation of Contaminated Sites*. The air sparge work plan was submitted to ADEC via email on January 2, 2012, and ADEC provided verbal approval of the work plan during the February 21, 2012 Site Characterization sub-group meeting.

2.0 Air Sparge Pilot Test System

2.1 Basis for the Approach

For the pilot test, the chemical of concern is sulfolane. Previous work, including monitoring of sulfolane removal across the existing onsite groundwater remediation system and supplementary bench tests, suggested that sulfolane may be removed via a combination of abiotic reactions involving iron/manganese oxidation, as well as biological degradation. These mechanisms appeared to be initiated via the introduction of air to the groundwater. The specific proposed sulfolane degradation mechanisms and supporting bench testing results were presented in a technical memorandum which was included as Appendix B in the *Draft Onsite Feasibility Study* (Arcadis, 2012) submitted to ADEC on April 13, 2012.

The pilot test design includes sparge points (i.e., air injection wells) arranged in two rows perpendicular to the approximate direction of groundwater flow. The test design also includes the ability to periodically pulse the addition of air to either of the two rows of sparge points (northern line and southern line). The purposes for these aspects of the design are:

- To provide flexibility in managing the hydraulics of the system. As continuous air sparging can cause groundwater mounding or preferential flow paths in some systems, pulsing is a means to enhance groundwater flow and distribution through the treatment zone.
- To provide flexibility in managing redox conditions/dissolved oxygen in the groundwater. As it is believed that some sulfolane degradation mechanisms may be concurrent with iron/manganese oxidation, pulsing is a means to allow some reduced iron/manganese to penetrate into the treatment zone, potentially enhancing sulfolane removal.

2.2 System Description

A schematic of the air sparge pilot system is provided on Figure 1. As shown on the figure, the pilot test area is located in the northern portion of NPR along the western side of the railroad tracks. The site location was selected to be within the dissolved-phase sulfolane plume and outside the dissolved-phase benzene plume, as detailed in the *Site Characterization Report-Through 2011* (Barr, December 2012). As shown on Figure 1, the system includes the following series of monitoring wells:

- An upgradient well for monitoring influent groundwater quality (AS-MW-8)
- A series of wells down the center line of the pilot system (AS-MW-6, AS-MW-5, AS-MW-2)

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- A series of wells outside of the system perimeter to the West (AS-MW-3, AS-MW-4)
- A series of wells outside of the system perimeter to the East (AS-MW-7, AS-MW-1)

The system also includes three monitoring point nests (MP-1, MP-2, MP-3), for the purpose of evaluating the radius of influence (ROI) of the sparge points in the aquifer. A cross section of sparge point AS-7, along with the monitoring points, is shown on Figure 2. Each sparge point consists of a 2-foot well screen installed approximately 20 feet below the water table.

Boring logs for the monitoring wells, air sparge points, and monitoring points are included in Attachment A.

In accordance with the work plan, an undisturbed soil core was collected during installation of AS-7. A hollow-stem auger rig with a 2-foot-long, 3-inch-diameter split spoon sampler with Lexan™ liners was used to collect the core from 27.5 feet (ft) to 29.5 ft with as little disturbance to the pore structure as possible. Upon retrieval, the 2-foot core was placed vertically, immediately flash frozen using dry ice and shipped with fresh dry ice to Core Laboratories of Bakersfield, California for analysis of air/water capillary drainage. The Air-Water Capillary Pressure Drainage (AWCD), Method ASTM D6836, centrifugal method was utilized to measure the amount of water extracted from a water-saturated sample under increasing amounts of negative pressure. Laboratory results are included as Attachment B. This data will aid in the design and operation of a potential full-scale air sparge system.

2.3 System Operation and Start-up

On March 7, 2012, FHRA began operation of the pilot system by supplying compressed air to the sparge points. The system layout and monitoring well locations are shown on Figure 1. The northern air line supplies air to AS-1, AS-2, AS-3, and AS-4, and was initially set up to maintain continuous operation. The system is designed to allow pulsing of each line by restricting air flow with a motor-operated valve (MOV). The northern line is controlled by MOV-05880 and the southern line by MOV-05881. The southern air line supplies air to AS-5, AS-6, AS-7, and AS-8 and was initially set to pulse every 6 hours (6 hours of active operation following by 6 hours with no flow).

The three monitoring point nests constructed around sparge point AS-7 are used as observation points to aid in evaluation of the air sparge ROI. Head-space pressure was initially measured weekly at each

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monitoring point. A detected increase in head-space pressure is indicative of the respective zone of the monitoring point lying within the area of influence of the air sparge point. As the pilot test has progressed, the monitoring frequency has been reduced during periods without changes to the operating setup, and in November 2012 freezing of the monitoring points prevented additional measurements.

Air flowrate and pressure were initially measured weekly at the compressor discharge and near the riser piping for each sparge point. Valving at each sparge point is utilized as necessary to achieve a similar air flowrate at each sparge point. As the pilot test has progressed, the monitoring frequency has been reduced during periods without changes to the operating setup.

Groundwater samples for laboratory analysis have been collected from the monitoring wells prior to operation and during active operation of the air sparge pilot system. Samples were collected weekly through the first 23 weeks of operation and then bi-weekly through the end of November 2012. This sampling is conducted in accordance with the *Revised Sampling and Analysis Plan* for the NPR Site (Arcadis, August 2012). Field monitoring, including depth to groundwater and dissolved oxygen measurements, has also been performed at each monitoring well on a similar frequency. System performance monitoring is further described in Section 3.

3.0 Performance Monitoring

3.1 Start-up and ROI Determination

The pilot test was started at 10:35 p.m. on March 7, 2012. Initial monitoring, consisting of head-space pressure readings and depth to water measurements at the sparge monitoring point nests, was conducted to evaluate the ROI from a given sparge point (AS-7). Initially, AS-7 was the only sparge point active along the southern line.

Field monitoring results completed following startup are shown in Table 1, and the results suggest that the ROI for the pilot test objectives (sulfolane removal) was greater than 15 feet from AS-7 based on (1) increased dissolved oxygen and (2) localized groundwater mounding. The air flowrate at AS-7 was 37 standard cubic feet per minute (SCFM) during startup monitoring. Figure 2 illustrates the dissolved oxygen concentrations measured in the nested monitoring points less than 48 hours after startup. The concentrations ranged from 1.61 mg/L in the deep MP-2D to 14.1 mg/L in MP-2C. The air sparge system had several periods of downtime during the initial 48 hours after startup as operational issues were

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resolved; however, the background dissolved oxygen concentration ranged from 0.1 to 0.4 mg/L, therefore an increase was observed at each interval in each monitoring point.

The ROI of an air sparge system can also be evaluated based on the displacement of water, as measured by an increase in the head-space pressure. This evaluation is typical for sites with dissolved-phase petroleum hydrocarbons which, in addition to increased dissolved oxygen, rely upon saturated-zone airflow to promote volatilization. As shown in Table 1 and on Figure 3, air pressure in excess of 100 inches of water was measured at observation well MP-2, located approximately 5 feet from AS-7, which indicates that MP-2 was within the portion of the aquifer with displacement of water influenced by air injection. Lower air pressures on the order of two inches of water was observed at MP-3, located 10 feet from AS-7, which indicates that MP-3 was on the fringes of the portion of the aquifer with displacement of air. Minimal (0.01 feet) air pressure was observed at MP-1, located 15 feet from AS-7. This result indicates that the air sparge ROI for water displacement exceeded 5 feet under startup conditions but was less than 15 feet.

3.2 Operational Data

Approximately weekly measurements of air flowrate and pressure were conducted at each air sparge point and the results are summarized in Table 2. Initially, the air flowrate at each air sparge point typically ranged from 25 to 45 SCFM. As described in the work plan and in Section 2, the southern injection line (AS-5, AS-6, AS-7, AS-8) initially had pulsed operation (six hours on followed by six hours off) and in some cases the flowrate is noted as “Off” in Table 2, as the monitoring event was conducted during a period of no air flow to the southern line. The results in Table 2 indicate that generally consistent air flowrate and pressure have been maintained during operation. As a result, the pilot test has not created short circuiting, which would be noted by increased air flowrate at an individual sparge point; or aquifer/sparge point fouling, which would be indicated by decreased air flowrate and increased pressure at an individual sparge point or at multiple locations.

During Week 18 of the pilot test, a series of changes were initiated to the air injection regime to evaluate the operating conditions necessary to maintain removal of sulfolane.

- During Week 18 of operation (week of July 9, 2012), the system was adjusted to allow continuous operation of the southern injection line and the northern injection line was turned off.

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Previously, the northern injection line operated continuously and the southern line had pulsed operation. Following the changes, the air flowrate at each air sparge point on the southern injection line typically ranged from 30 to 40 SCFM.

- During Week 22 of operation (August 9, 2012), the system was adjusted to reduce flow in the southern injection line to 20 to 23 SCFM at each air sparge point. The northern injection line remained off.
- During Week 23 of operation (August 14, 2012), the system was adjusted to pulsed operation of the southern injection line (six hours on followed by six hours off) with the northern injection line off. The air flowrate at each air sparge point when active ranged from 20-23 SCFM.
- During Week 28 of operation (September 24, 2012), the air injection rate was increased to approximately 30 to 35 SCFM at each air sparge point.
- During Week 36 of operation (November 15, 2012) air sparge points AS-6 and AS-8 were turned off, thus leaving AS-5 and AS-7 as the only active air sparge points. The purpose was to monitor the effect of reduced overall air injection.

As previously described, monitoring points were installed to measure the pressure at different intervals and allow evaluation of the ROI (as discussed in Section 3.1). Following the initial startup measurements, measurements of pressure were collected routinely (weekly for the first 22 weeks) at the monitoring points and the results are shown in Table 3. Also included in Table 3 is the status of the MOVs which regulate flow to the northern line (MOV-05880) and southern line (MOV-05881). The pressure measured at the monitoring points indicates increased pressure, and thus water displacement, at each monitoring point (Table 3). However, intervals MP-2A and MP-3B have shown limited pressure increase during most monitoring events (with a few events showing elevated pressure similar to the other monitoring points), and it is unclear why these locations are showing limited pressure increase as other intervals at the same monitoring point, or at the same depth in other monitoring points, have shown increased pressure. The area boring logs (Attachment A) did not indicate any geological conditions that would indicate preferential flowpaths. Since the limited pressure increase at MP-2A and MP-3B has been measured since startup, it is not anticipated to be the result of aquifer or well screen fouling.

The work plan called for weekly depth to groundwater and field monitoring (including dissolved oxygen and ORP [oxidation/reduction potential]) at the monitoring points. However, these data were not

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collected due to safety concerns associated with the location of the monitoring points and the potential for preferential venting of injected air.

Since Week 4 of the pilot test, measurements of the groundwater elevation at the monitoring wells have been completed during each monitoring event and the results are included in Table 4. As previously noted, safety concerns were identified regarding collection of data at the monitoring points and monitoring wells during active operation, so the depth to water measurements were collected with the system temporarily shut off. The groundwater elevation was contoured; however, the results do not show a clear gradient and are likely influenced by the distance of each monitoring well to a sparge point and potential localized mounding. Example figures providing the groundwater table elevation measurements for the Week 5 and 20 monitoring events are included in Attachment C.

3.3 Monitoring Data

The locations of the monitoring wells associated with the air sparge pilot test are shown on Figure 1. As described in Section 2, AS-MW-8 was installed to evaluate the sulfolane concentration upgradient of the air sparge pilot test area. Monitoring wells AS-MW-5 and AS-MW-6 were installed downgradient of the southern line of air sparge points, which were initially operated on a pulsed basis (six hours on, six hours off). Monitoring well AS-MW-2 was installed downgradient of the northern line of air sparge points which was initially operated continuously. Monitoring wells AS-MW-1, AS-MW-3, AS-MW-4, and AS-MW-7 were installed around the perimeter of the pilot test area to allow evaluation of the ROI for potential sulfolane degradation.

Analytical monitoring included an initial background monitoring event conducted on February 18 through 20, 2012 to evaluate conditions prior to startup of the air sparge system. Laboratory analysis during the pilot testing has included sulfolane, dissolved iron, dissolved manganese, total organic carbon (TOC), total kjeldahl nitrogen (TKN) and total phosphorus. Additionally, the sample collected from AS-MW-8 during the background monitoring event was analyzed for volatile organic compounds (VOCs). The purpose for the VOC analysis was to confirm there were not substantial levels of petroleum hydrocarbons that could potentially impact the pilot test. Following startup, monitoring was conducted at each monitoring well on a weekly (first 23 weeks) or bi-weekly (weeks 25 through 37) frequency and results through November 2012 are included in Table 4. The laboratory completed a review for tentatively identified compounds (TICs) to scan for potential intermediate byproducts of sulfolane destruction during

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each monitoring event, with the exception of the Week 9 event in which the TIC scan was erroneously not completed.

In general, a decrease in the sulfolane concentration was observed in each monitoring well in the pilot test area following startup. The degree of sulfolane removal appears to correlate with the increase in dissolved oxygen concentration and ORP measured, as well as decreases in dissolved iron and manganese. Figure 4 is a principal component plot of the pilot data demonstrating a negative correlation between sulfolane concentration and dissolved oxygen /ORP. Also evident in the plot is a positive correlation between sulfolane and dissolved (i.e., reduced) manganese. It should be noted that the majority of the dissolved iron measurements were non-detect following initiation of the pilot test; thus, a strong correlation with sulfolane concentration is not shown. This is not surprising, as iron oxidation is generally more rapid than manganese oxidation. There have been no indicators of fouling at the air sparge points based on consistent pressure and air flow rate measurements.

The following is a summary of the monitoring results presented in Table 4 (laboratory reports are included as Attachment D). For ease of analysis, discussion of the results has been categorized based on the location of the monitoring wells.

Center Treatment Zone (AS-MW-2, AS-MW-5, and AS-MW-6)

- AS-MW-2, which is located downgradient of the northern line, had the most rapid sulfolane removal. The sulfolane concentration decreased below the limit of quantitation (LOQ) by the Week 3 monitoring event and has remained below the detection limit in each subsequent monitoring event. AS-MW-5 and AS-MW-6, which are located downgradient of the southern line, demonstrated increasing sulfolane degradation with each week of operation. At AS-MW-5, the sulfolane concentration was below the LOQ by the Week 7 monitoring event and has remained below the detection limit in each subsequent monitoring event. At AS-MW-6, the sulfolane concentration was below the LOQ by the Week 10 monitoring event and has remained below the detection limit in each subsequent monitoring event.
- The dissolved oxygen concentration at AS-MW-2 was quickly elevated following active operation, with concentrations 12 mg/L or greater from Week 2 through Week 20. The dissolved oxygen concentration at AS-MW-2 changed in response to deactivation of the northern line in Week 18, and stabilized between 3 and 4 mg/L in the Week 25 to Week 29 monitoring events.

The dissolved oxygen concentration at AS-MW-2 increased after Week 29 to range between 7.9 and 11.16 mg/L through Week 37 in response to the increased air flow rate to the southern line. At AS-MW-5 and AS-MW-6, the dissolved oxygen concentrations steadily increased with active operation (typically greater than 13 mg/L). In these wells, the dissolved oxygen concentrations changed in Week 22 in response to a decrease in the air injection rate in the southern line. Conversely, the dissolved oxygen concentrations in these wells increased in Weeks 29 through 37, when the air injection rate to the southern line was increased.

- The dissolved iron concentrations at AS-MW-2, AS-MW-5, and AS-MW-6 decreased upon active operation of the air sparge system with concentrations quickly dropping below the detection limit. This result was anticipated based on the introduction of dissolved oxygen into the aquifer creating conditions for the oxidation and precipitation of iron. Low-level (j-flagged) concentrations of iron were reported in AS-MW-2 following deactivation of the northern injection line.
- The dissolved manganese concentrations at AS-MW-2, AS-MW-5, and AS-MW-6 have steadily declined upon active operation of the air sparge system. Similar to iron, this result was anticipated based on the introduction of dissolved oxygen into the aquifer creating conditions for the oxidation and precipitation of manganese. However, due to slower oxidation kinetics, changes in the dissolved manganese concentrations have shown steady decrease at each monitoring as opposed to the rapid decrease observed for dissolved iron. These data are indicative of an overall spreading of dissolved oxygen and oxidative conditions in the aquifer and provide evidence that short-circuiting is not occurring.

Western Perimeter (AS-MW-3 and AS-MW-4)

- Monitoring wells AS-MW-3 and AS-MW-4 have demonstrated slower decreases in sulfolane concentrations than the monitoring wells in the Central Treatment Zone. However, the sulfolane concentrations at both monitoring wells have been below the LOQ since Week 15 (at AS-MW-3) and Week 18 (at AS-MW-4). The results at these locations demonstrate the radius-of-influence of sulfolane treatment induced by the pilot test.
- The dissolved oxygen increase at AS-MW-3 and AS-MW-4 is not as pronounced as the other monitoring wells due to the more cross-gradient location of these wells. At AS-MW-3, the dissolved oxygen concentration generally increased with each week of operation, achieving a

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concentration greater than 7 mg/L during Week 18 and 19. The dissolved oxygen concentration at AS-MW-3 responded to deactivation of the northern line, and was less than 1 mg/L in the Week 25 to Week 27 monitoring events. In Weeks 29 through 37, an increase in air flow rate to the southern line resulted in an increase in the dissolved oxygen concentration at AS-MW-3 (from 0.56 mg/L up to 5.51 mg/L). At AS-MW-4, the dissolved oxygen concentration increased with each week of operation, reaching a concentration greater than 9 mg/L during the Week 19 event. The dissolved oxygen concentration showed less of an increase since deactivation of the northern line, with concentrations greater than 2 mg/L during the Week 25 to Week 29 monitoring events. However, during Weeks 31 through 37 the dissolved oxygen has increased ranging from 4.36 to 9.80 mg/L with increased air flow to the southern line.

- The dissolved iron concentrations at AS-MW-3 and AS-MW-4 have steadily decreased upon active operation of the air sparge system. The drop in the iron concentrations was not as rapid as the Central Treatment Zone monitoring wells due to a smaller increase in the dissolved oxygen concentrations.
- The dissolved manganese concentrations at AS-MW-3 and AS-MW-4 have steadily declined upon active operation of the air sparge system, although not to the degree of reduction observed in the Central Treatment Zone monitoring wells. Similar to iron, the degree of reduction was less due to smaller increases in the dissolved oxygen concentrations. As previously noted, with the slower reaction time, changes in the dissolved manganese concentrations are indicative of an overall spreading of dissolved oxygen and oxidative conditions in the aquifer and provide evidence that short-circuiting is not occurring.

Eastern Perimeter (AS-MW-1 and AS-MW-7)

- Monitoring wells AS-MW-1 and AS-MW-7 have demonstrated rapid sulfolane degradation with results of the Week 5 monitoring event below the LOQ at both locations. AS-MW-1 appears to be located along the eastern extent of the sulfolane treatment zone, as when system air flow was reduced during Week 22 through Week 27, detectable sulfolane concentrations were reported. When air flow was increased again in Week 27, the subsequent samples at AS-MW-1 during Weeks 29 through 37 demonstrate sulfolane concentrations below the LOQ. Results at AS-MW-7 have remained below the LOQ since the Week 5 monitoring event. Thus, to achieve complete

sulfolane removal at AS-MW-1, an air injection rate greater than 20 to 23 SCFM per injection point is necessary.

- The dissolved oxygen concentrations at AS-MW-1 and AS-MW-7 were quickly elevated following active operation, with concentrations typically greater than 12 mg/L. The dissolved oxygen concentration in AS-MW-1 has shown a smaller increase since deactivation of the northern line, with the concentration dropping below 1 mg/L during the Week 25 and 27 monitoring events. The dissolved oxygen concentration increased to greater than 2 mg/L during the Week 28 monitoring event following an increase in the air injection rate and remained elevated with a maximum concentration during the Week 33 monitoring event of 11.41 mg/L. At AS-MW-7, the dissolved oxygen concentration has remained elevated with the concentration remaining above 8 mg/L during the Week 23 and Week 25 monitoring events and above 13 mg/L during the Week 33, 35, and 37 monitoring events.
- The dissolved iron concentrations at AS-MW-1 and AS-MW-7 decreased upon active operation of the air sparge system with concentrations below the detection limit. As previously noted, this result was anticipated based on the introduction of dissolved oxygen into the aquifer creating conditions for the oxidation and precipitation of iron. Low-level (j-flagged) concentrations of iron were reported at AS-MW-7 in Weeks 25 through 37 following switching to air injection at only the southern line.
- The dissolved manganese concentrations at AS-MW-1 and AS-MW-7 have steadily declined upon active operation of the air sparge system, although not to the degree of reduction observed in the Central Treatment Zone monitoring wells.

Upgradient (AS-MW-8)

- The sulfolane concentration at the upgradient monitoring well (AS-MW-8) remained consistent through the first 6 weeks of the pilot test with concentrations ranging from 112 to 150 µg/L. However, a substantial decrease in the sulfolane concentration was reported during the Week 7 monitoring event (9.55 µg/L). Following the Week 7 event, the sulfolane concentration increased; however, the concentrations measured in subsequent weeks remained below the levels measured in Weeks 1 through 6. Over the entire pilot test, the sulfolane concentration measured has generally declined. The general decrease in sulfolane concentrations is likely not due to the operation of the air sparge system, but may be the result of increased groundwater recovery

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initiated in 2010 at the upgradient groundwater extraction system. A decrease in the sulfolane concentration has also been noted at nearby monitoring well MW-131, which will be further discussed in future quarterly groundwater monitoring reports.

- The dissolved oxygen concentrations at AS-MW-8, which is screened across the water table, have generally remained low and consistent with other areas of the site with an exception measured during the Week 7 monitoring event. This event occurred during a period of spring melting at which time a temporary increase in dissolved oxygen was observed, as the dissolved oxygen concentration was reduced to near background levels during the Week 8 monitoring event.
- The dissolved iron concentration at AS-MW-8 declined during the first 6 weeks of the pilot test, and results were below detection limits from Week 6 to Week 25. In monitoring conducted in Weeks 27 through 37, low-level (j-flagged) concentrations of dissolved iron have been reported.
- The manganese concentrations measured at AS-MW-8 have fluctuated, but did not have the general declining trend noted in the monitoring wells within the pilot test area (AS-MW-1 through AS-MW-7).

TIC Results

The TIC scans completed as part of each sampling event (Attachment D), with the exception of Week 9 as previously noted, were examined for potential sulfolane degradation intermediates based on the following criteria:

- Chromatographic peaks that were flagged by the lab, and
- Were not associated with internal standards (i.e. the method blank), and
- Were present in downgradient wells but not the upgradient well.

While some chromatographic peaks were sporadically detected over the course of the pilot test, they were generally present in both upgradient and downgradient wells, inconsistently present from one event to the next, and not consistent with potential intermediate compounds suggested in previous work.

Evaluation of the analytical methods and identification of degradation intermediates is ongoing within the Degradation Subgroup, thus further discussion and evaluation of the pilot test results is anticipated.

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Additional Water Quality Results

At the outset of the pilot study, a VOC scan was conducted to identify any additional compounds that might impact performance or operation of the system. The only VOC detected during the pre-startup background monitoring was a low-level concentration of MTBE (Table 5), which confirms there were not substantial levels of petroleum hydrocarbons in the test area.

Additional analysis was conducted at AS-MW-2 (downgradient) and AS-MW-8 (upgradient) to evaluate any changes in the aesthetic water quality in response to operation of the air sparge system (Table 6). The additional analysis included total iron, total manganese, total copper, color, turbidity, total suspended solids (TSS), total dissolved solids (TDS), alkalinity, total calcium, pH (laboratory), sulfate, odor (TON), and heterotrophic plate count (HPC). The following observations were made based on these data:

- Based on these data, as well as weekly monitoring, air sparging should generally decrease the amount of dissolved iron and manganese in the groundwater, which is a desirable outcome from a water quality standpoint.
- Air sparging did not appear to adversely impact the microbial quality (i.e., HPC) or odor (TON) of the water relative to the upgradient water.
- Turbidity, TSS and total copper may have increased slightly after air sparging, but remained relatively low.
- Air sparging had a significant impact on groundwater alkalinity, which decreased, and pH, which increased. Both of these effects are consistent with offgassing of dissolved carbon dioxide during sparging. This is a desirable outcome from a water quality standpoint, as low pH and high alkalinity are factors that can contribute to copper corrosivity of the water.
- The sulfate concentration increased from the upgradient to the downgradient well, but would not be expected to create any aesthetic issues as it is well below EPA's secondary drinking water maximum contaminant limit (250 mg/L). The secondary standards are non-mandatory guidelines for aesthetic consideration.

3.4 Potential Degradation Intermediates

Previous work has suggested possible intermediates following aerobic sulfolane degradation. As described above, the laboratory completed a review of TICs, however, accumulation of degradation

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intermediates has not been observed. This is an expected outcome, as the possible intermediates are thought to be more biodegradable than sulfolane, particularly under aerobic conditions. However, as previously noted, evaluation of the analytical methods and identification of degradation intermediates is ongoing within the Degradation Subgroup, thus further discussion and evaluation of the pilot test results is planned.

4.0 Progress Summary

A review of the data generated from the first 37 weeks of the air sparge pilot test suggests that air sparging is an effective remediation strategy to enhance the degradation of sulfolane in the impacted groundwater at NPR.

Radius of Influence

ROI testing has indicated that an air flow of 37 SCFM through a shallow (20 feet) sparge point will force oxygen throughout the vertical soil profile above the screened interval with horizontal impacts greater than 15 feet based on increased dissolved oxygen. The uniformity of the effective treatment zone and lack of short-circuiting is further demonstrated by the observed declining trends in dissolved iron and manganese, which occurred gradually over the course of the test. The radius of influence based on several factors (increased dissolved oxygen, decreased iron and manganese) has been demonstrated throughout the treatment zone with pulsed operation and at lower air flow rates (20 to 23 SCFM with 4 active air injection points).

Sulfolane Degradation

Declining sulfolane concentrations in the monitoring wells downgradient from the intermittently-operated air injection line and the continuously-operated air injection line demonstrate that pulsed operation is also effective at promoting sulfolane degradation. The data demonstrate sulfolane degradation in association with higher dissolved oxygen, higher ORP, and declining dissolved iron and manganese concentrations. This is consistent with previous observations from the remediation system and associated bench tests.

The effect of air sparge system operation on sulfolane degradation was further demonstrated in Weeks 23 through 37, in which dissolved oxygen concentration was varied by varying the air input to the system, resulting in the expected changes in sulfolane concentrations at AS-MW-1 (i.e. as dissolved oxygen decreased, sulfolane concentration increased, and as dissolved oxygen increased, sulfolane concentration

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decreased). For the pilot test, an air injection rate of greater than 20 to 23 SCFM was necessary in the southern line to demonstrate sulfolane degradation to below the LOQ at AS-MW-1. At the other monitoring wells, a pulsed air injection rate of 20 to 23 SCFM was sufficient to maintain sulfolane degradation to below the LOQ.

Aesthetic Quality

No negative impacts to aesthetic water quality have been observed as a result of air sparging based on analysis of upgradient and downgradient water quality.

Operational Aspects

The pilot test has not encountered problems associated with short circuiting or fouling during the 37-week pilot period. The steady decline in dissolved manganese concentrations in the downgradient monitoring wells over the course of the study period is an indication of the effective spreading of dissolved oxygen throughout the treatment zone.

5.0 Ongoing Monitoring

The pilot test is currently being continued with only two injection points (AS-5 and AS-7) along the south line operating for evaluation of the potential minimum air flowrate or dissolved oxygen concentration that is necessary to promote sulfolane removal. Due to freezing of the monitoring wells, no sampling was conducted in December 2012. FHRA is planning to utilize steam equipment to thaw the monitoring wells in January 2013 and perform analytical monitoring. Upon completion of this monitoring event, FHRA is planning to halt operation of the air sparge pilot system but plans to continue monitoring to evaluate the timeframe for likely rebound in sulfolane concentrations. Results of this monitoring will be presented in future quarter groundwater monitoring reports.

Attachments:

- Attachment A Boring Logs
- Attachment B Air/Water Capillary Pressure Summary
- Attachment C Air Sparge Pilot Test Groundwater Elevation-Week 5 and 20 Events
- Attachment D Laboratory Reports with Tentatively Identified Compounds

Tables

Table 1
Startup Field Monitoring Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

	Startup-Initial Conditions	
	Flow (scfm)	Pressure (psi)
AS-1	55	9.5
AS-2	28	8
AS-3	42	8.5
AS-4	33	7.5
AS-5	0	0
AS-6	0	0
AS-7	37	8.8
AS-8	0	0

Note: Startup at 10:35 pm, March 7, 2012. AS-5, AS-6, and AS-8 were initially isolated to allow radius of influence monitoring at AS-7.

	Depth to Water Measurements (feet)	
	Background	Post-Startup
	3/7/2012 2:35 PM	3/8/2012 4:40 PM
MP-1 A	14.61	13.8
MP-1 B	14.54	14.11
MP-1 C	14.51	14.25
MP-2 A	14.18	Rising/Unstable
MP-2 B	14.14	Rising/Unstable
MP-2 C	14.27	Rising/Unstable
MP-2 D	14.15	14.01
MP-3 A	14.59	Rising/Unstable
MP-3 B	14.5	13.82
MP-3 C	14.61	14.25

	Monitoring Point Pressure (inches water)
	Post-Startup 3/7/2012 11:30:00 PM
MP-1 A	0.01
MP-1 B	0.01
MP-1 C	0.01
MP-2 A	0
MP-2 B	>100
MP-2 C	>100
MP-2 D	11
MP-3 A	0.9
MP-3 B	2.5
MP-3 C	2.25

	Monitoring Point Dissolved Oxygen (mg/L)	
MP-1 A	2.2	3/9/12 9:45 PM
MP-1 B	10.52	3/9/12 10:15 PM
MP-1 C	10.23	3/9/12 9:35 PM
MP-2 A	7.24	3/9/12 7:50 PM
MP-2 B	8.95	3/9/12 8:30 PM
MP-2 C	14.1	3/9/12 9:00 PM
MP-2 D	1.61	3/9/12 7:40 PM
MP-3 A	9.21	3/9/12 3:30 PM
MP-3 B	10.51	3/9/12 4:00 PM
MP-3 C	7.19	3/9/12 4:00 PM

Note: Background dissolved oxygen concentration 0.1 to 0.4 mg/L

Table 2
Flowrate and Pressure Summary - Sparge Points
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Pilot Test Duration	Sparge Point	Date	Air Flowrate (SCFM)	Pressure (psi)
Week 1	AS-1	3/14/12 20:30	36	6.8
Week 1	AS-1	3/15/12 18:06	37	7.3
Week 2	AS-1	3/21/12 17:15	25	7.0
Week 3	AS-1	3/27/12 11:50	33	7.1
Week 3	AS-1	3/28/12 17:30	33	7.2
Week 4	AS-1	4/4/12 23:40	35	7.2
Week 4	AS-1	4/5/12 3:55	40	8.0
Week 5	AS-1	4/7/12 1:45	25	7.1
Week 7	AS-1	4/21/12 16:30	36.5	7.5
Week 7	AS-1	4/25/12 16:50	57	7.9
Week 8	AS-1	5/2/12 21:00	43	7.4
Week 10	AS-1	5/12/12 20:10	36	7.1
Week 11	AS-1	5/23/12 11:55	25	7.1
Week 12	AS-1	5/29/12 11:00	32	7.5
Week 16	AS-1	6/28/12 14:35	32	8.0
Week 18	AS-1	7/9/12 14:20	35	8.2
Week 18	AS-1	7/12/12 10:05	Off	Off
Week 20	AS-1	7/26/12 12:00	Off	Off
Week 20	AS-1	7/26/12 15:00	Off	Off
Week 21	AS-1	7/30/12 10:00	Off	Off
Week 22	AS-1	8/9/12 9:20	Off	Off
Week 23	AS-1	8/14/12 9:55	Off	Off
Week 26	AS-1	9/4/12 14:15	Off	Off
Week 28	AS-1	9/19/12 14:35	Off	Off
Week 28	AS-1	9/19/12 14:50	Off	Off
Week 28	AS-1	9/20/12 12:00	Off	Off
Week 29	AS-1	9/27/12 12:00	Off	Off
Week 30	AS-1	10/1/12 15:30	Off	Off
Week 30	AS-1	10/3/12 14:00	Off	Off
Week 32	AS-1	10/16/12 13:15	Off	Off
Week 33	AS-1	10/25/12 10:25	Off	Off
Week 34	AS-1	10/31/12 14:30	Off	Off
Week 36	AS-1	11/15/12 14:00	Off	Off

Pilot Test Duration	Sparge Point	Date	Air Flowrate (SCFM)	Pressure (psi)
Week 1	AS-2	3/14/12 20:30	32	7.8
Week 1	AS-2	3/15/12 18:06	33	8.2
Week 2	AS-2	3/21/12 17:15	19	8.0
Week 3	AS-2	3/27/12 11:51	41	7.8
Week 3	AS-2	3/28/12 17:30	33	8.0
Week 4	AS-2	4/4/12 23:40	40	8.0
Week 4	AS-2	4/5/12 3:56	40	8.0
Week 5	AS-2	4/7/2012 1.:45	31	7.4
Week 7	AS-2	4/21/12 16:30	52	8
Week 7	AS-2	4/25/12 16:50	48	8.2
Week 8	AS-2	5/2/12 21:00	52	8.0
Week 10	AS-2	5/12/12 20:10	44.5	7.4
Week 11	AS-2	5/23/12 11:55	34	7.5
Week 12	AS-2	5/29/12 11:00	42	8.0
Week 16	AS-2	6/28/12 14:35	34	8.2
Week 18	AS-2	7/9/12 14:20	34	8.4
Week 18	AS-2	7/12/12 10:05	Off	Off
Week 20	AS-2	7/26/12 12:00	Off	Off
Week 20	AS-2	7/26/12 15:00	Off	Off
Week 21	AS-2	7/30/12 10:00	Off	Off
Week 22	AS-2	8/9/12 9:20	Off	Off
Week 23	AS-2	8/14/12 9:55	Off	Off
Week 26	AS-2	9/4/12 14:15	Off	Off
Week 28	AS-2	9/19/12 14:35	Off	Off
Week 28	AS-2	9/19/12 14:50	Off	Off
Week 28	AS-2	9/20/12 12:00	Off	Off
Week 29	AS-2	9/27/12 12:00	Off	Off
Week 30	AS-2	10/1/12 15:30	Off	Off
Week 30	AS-2	10/3/12 14:00	Off	Off
Week 32	AS-2	10/16/12 13:15	Off	Off
Week 33	AS-2	10/25/12 10:25	Off	Off
Week 34	AS-2	10/31/12 14:30	Off	Off
Week 36	AS-2	11/15/12 14:00	Off	Off

Table 2
Flowrate and Pressure Summary - Sparge Points
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Pilot Test Duration	Sparge Point	Date	Air Flowrate (SCFM)	Pressure (psi)
Week 1	AS-3	3/14/12 20:30	36	6.8
Week 1	AS-3	3/15/12 18:06	37	7.2
Week 2	AS-3	3/21/12 17:15	22	7.0
Week 3	AS-3	3/27/12 11:52	35	6.8
Week 3	AS-3	3/28/12 17:30	29	7.1
Week 4	AS-3	4/4/12 23:40	37	7.0
Week 4	AS-3	4/5/12 3:56	40	7.0
Week 5	AS-3	4/7/12 1:45	28	6.7
Week 7	AS-3	4/21/12 16:30	45	7
Week 7	AS-3	4/25/12 16:50	45	7.5
Week 8	AS-3	5/2/12 21:00	43	7.0
Week 10	AS-3	5/12/12 20:10	38.5	6.5
Week 11	AS-3	5/23/12 11:55	28	6.9
Week 12	AS-3	5/29/12 11:00	36	7.2
Week 16	AS-3	6/28/12 14:35	31	7.4
Week 18	AS-3	7/9/12 14:20	30	7.6
Week 18	AS-3	7/12/12 10:05	Off	Off
Week 20	AS-3	7/26/12 12:00	Off	Off
Week 20	AS-3	7/26/12 15:00	Off	Off
Week 21	AS-3	7/30/12 10:00	Off	Off
Week 22	AS-3	8/9/12 9:20	Off	Off
Week 23	AS-3	8/14/12 9:55	Off	Off
Week 26	AS-3	9/4/12 14:15	Off	Off
Week 28	AS-3	9/19/12 14:35	Off	Off
Week 28	AS-3	9/19/12 14:50	Off	Off
Week 28	AS-3	9/20/12 12:00	Off	Off
Week 29	AS-3	9/27/12 12:00	Off	Off
Week 30	AS-3	10/1/12 15:30	Off	Off
Week 30	AS-3	10/3/12 14:00	Off	Off
Week 32	AS-3	10/16/12 13:15	Off	Off
Week 33	AS-3	10/25/12 10:25	Off	Off
Week 34	AS-3	10/31/12 14:30	Off	Off
Week 36	AS-3	11/15/12 14:00	Off	Off

Pilot Test Duration	Sparge Point	Date	Air Flowrate (SCFM)	Pressure (psi)
Week 1	AS-4	3/14/12 20:30	36	7.9
Week 1	AS-4	3/15/12 18:06	42	8.2
Week 2	AS-4	3/21/12 17:15	19	8.0
Week 3	AS-4	3/27/12 11:52	29	7.8
Week 3	AS-4	3/28/12 17:30	34	8.1
Week 4	AS-4	4/4/12 23:40	33	8.0
Week 4	AS-4	4/5/12 3:57	33	8.0
Week 5	AS-4	4/7/12 1:45	23	7.6
Week 7	AS-4	4/21/12 16:30	35	8.0
Week 7	AS-4	4/25/12 16:50	45	8.2
Week 8	AS-4	5/2/12 21:00	44	7.9
Week 10	AS-4	5/12/12 20:10	36.5	7.5
Week 11	AS-4	5/23/12 11:55	26	7.6
Week 12	AS-4	5/29/12 11:00	27	8
Week 16	AS-4	6/28/12 14:35	28	8.1
Week 18	AS-4	7/9/12 14:20	30	8.2
Week 18	AS-4	7/12/12 10:05	Off	Off
Week 20	AS-4	7/26/12 12:00	Off	Off
Week 20	AS-4	7/26/12 15:00	Off	Off
Week 21	AS-4	7/30/12 10:00	Off	Off
Week 22	AS-4	8/9/12 9:20	Off	Off
Week 23	AS-4	8/14/12 9:55	Off	Off
Week 26	AS-4	9/4/12 14:15	Off	Off
Week 28	AS-4	9/19/12 14:35	Off	Off
Week 28	AS-4	9/19/12 14:50	Off	Off
Week 28	AS-4	9/20/12 12:00	Off	Off
Week 29	AS-4	9/27/12 12:00	Off	Off
Week 30	AS-4	10/1/12 15:30	Off	Off
Week 30	AS-4	10/3/12 14:00	Off	Off
Week 32	AS-4	10/16/12 13:15	Off	Off
Week 33	AS-4	10/25/12 10:25	Off	Off
Week 34	AS-4	10/31/12 14:30	Off	Off
Week 36	AS-4	11/15/12 14:00	Off	Off

Table 2
Flowrate and Pressure Summary - Sparge Points
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Pilot Test Duration	Sparge Point	Date	Air Flowrate (SCFM)	Pressure (psi)
Week 1	AS-5	3/14/12 20:30	41	8.0
Week 1	AS-5	3/15/12 18:06	40	8.3
Week 3	AS-5	3/27/12 11:54	20	6.2
Week 3	AS-5	3/28/12 17:30	34	8.5
Week 4	AS-5	4/4/12 23:40	Off	Off
Week 4	AS-5	4/5/12 4:00	Off	Off
Week 5	AS-5	4/7/12 1:45	Off	Off
Week 7	AS-5	4/21/12 16:30	25	7.0
Week 7	AS-5	4/25/12 16:50	44	8.8
Week 8	AS-5	5/2/12 21:00	Off	Off
Week 10	AS-5	5/12/12 20:10	38	8.1
Week 11	AS-5	5/23/12 11:55	28	8.2
Week 12	AS-5	5/29/12 11:00	Off	Off
Week 16	AS-5	6/28/12 14:45	30	9.2
Week 18	AS-5	7/9/12 14:10	30	9.4
Week 18	AS-5	7/12/12 10:35	38	9.0
Week 20	AS-5	7/26/12 11:45	36	9.6
Week 20	AS-5	7/26/12 15:00	33	9.6
Week 21	AS-5	7/30/12 9:45	28	9.1
Week 22	AS-5	8/9/12 9:25	22	7.0
Week 23	AS-5	8/14/12 10:00	22	7.2
Week 26	AS-5	9/4/12 14:20	28	8.8
Week 28	AS-5	9/19/12 14:35	27	8.4
Week 28	AS-5	9/19/12 14:50	20	7.2
Week 28	AS-5	9/20/12 12:00	35	8.5
Week 29	AS-5	9/27/12 12:00	35	8.8
Week 30	AS-5	10/1/12 15:30	31	8.6
Week 30	AS-5	10/3/12 14:05	32	8.8
Week 32	AS-5	10/16/12 13:15	31	8.4
Week 33	AS-5	10/25/12 10:25	34	8.0
Week 34	AS-5	10/31/12 14:30	27	7.8
Week 36	AS-5	11/15/12 14:00	40	8.8

Pilot Test Duration	Sparge Point	Date	Air Flowrate (SCFM)	Pressure (psi)
Week 1	AS-6	3/14/12 20:30	37	8.0
Week 1	AS-6	3/15/12 18:06	33	8.4
Week 3	AS-6	3/27/12 11:54	20	6.2
Week 3	AS-6	3/28/12 17:30	30	8.0
Week 4	AS-6	4/4/12 23:40	Off	Off
Week 4	AS-6	4/5/12 4:00	Off	Off
Week 5	AS-6	4/7/12 1:45	33	7.9
Week 7	AS-6	4/21/12 16:30	25	6.8
Week 7	AS-6	4/25/12 16:50	45	8.8
Week 8	AS-6	5/2/12 21:00	Off	Off
Week 10	AS-6	5/12/12 20:10	44	8.1
Week 11	AS-6	5/23/12 11:55	34	8.0
Week 12	AS-6	5/29/12 11:00	Off	Off
Week 16	AS-6	6/28/12 14:45	40	9.0
Week 18	AS-6	7/9/12 14:10	53	9.2
Week 18	AS-6	7/12/12 10:35	50	8.9
Week 20	AS-6	7/26/12 11:45	46	9.4
Week 20	AS-6	7/26/12 15:00	32	9.1
Week 21	AS-6	7/30/12 9:45	30	8.8
Week 22	AS-6	8/9/12 9:25	23	7.0
Week 23	AS-6	8/14/12 10:00	22	7.0
Week 26	AS-6	9/4/12 14:20	27	8.1
Week 28	AS-6	9/19/12 14:35	27	7.8
Week 28	AS-6	9/19/12 14:50	22	6.8
Week 28	AS-6	9/30/12 12:00	35	8.5
Week 29	AS-6	9/27/12 12:00	35	8.4
Week 30	AS-6	10/1/12 15:30	30	8.2
Week 30	AS-6	10/3/12 14:05	30	8.2
Week 32	AS-6	10/16/12 13:15	33	8.1
Week 33	AS-6	10/25/12 10:25	33	7.5
Week 34	AS-6	10/31/12 14:30	26	7.6
Week 36	AS-6	11/15/12 14:00	Off	Off

Table 2
Flowrate and Pressure Summary - Sparge Points
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Pilot Test Duration	Sparge Point	Date	Air Flowrate (SCFM)	Pressure (psi)
Week 1	AS-7	3/14/12 20:30	37	7.9
Week 1	AS-7	3/15/12 18:06	35	8.2
Week 3	AS-7	3/27/12 11:53	19	5.8
Week 3	AS-7	3/28/12 17:30	27	8.1
Week 4	AS-7	4/4/12 23:40	Off	Off
Week 4	AS-7	4/5/12 3:58	Off	Off
Week 5	AS-7	4/7/2012 1.:45	27	7.8
Week 7	AS-7	4/21/12 16:30	26	6.2
Week 7	AS-7	4/25/12 16:50	46	8.6
Week 8	AS-7	5/2/12 21:00	Off	Off
Week 10	AS-7	5/12/12 20:10	42	8.0
Week 11	AS-7	5/23/12 11:55	33	8.0
Week 12	AS-7	5/29/12 11:00	Off	Off
Week 16	AS-7	6/28/12 14:45	32	9.1
Week 18	AS-7	7/9/12 14:10	38	9.2
Week 18	AS-7	7/12/12 10:35	53	8.8
Week 20	AS-7	7/26/12 11:45	47	9.2
Week 20	AS-7	7/26/12 15:00	35	9.0
Week 21	AS-7	7/30/12 9:45	31	8.8
Week 22	AS-7	8/9/12 9:25	22	6.7
Week 23	AS-7	8/14/12 10:00	22	6.7
Week 26	AS-7	9/4/12 14:20	27	8.2
Week 28	AS-7	9/19/12 14:35	25	8.0
Week 28	AS-7	9/19/12 14:50	21	6.6
Week 28	AS-7	9/20/12 12:00	35	8.5
Week 29	AS-7	9/27/12 12:00	35	8.6
Week 30	AS-7	10/1/12 15:30	33	8.2
Week 30	AS-7	10/3/12 14:05	30	8.2
Week 32	AS-7	10/16/12 13:15	29	8.2
Week 33	AS-7	10/25/12 10:25	29	7.6
Week 34	AS-7	10/31/12 14:30	29	7.6
Week 36	AS-7	11/15/12 14:00	34	8.4

Pilot Test Duration	Sparge Point	Date	Air Flowrate (SCFM)	Pressure (psi)
Week 1	AS-8	3/14/12 20:30	34	6.8
Week 1	AS-8	3/15/12 18:06	33	7.0
Week 3	AS-8	3/27/12 11:53	17	4.8
Week 3	AS-8	3/28/12 17:30	25	7.0
Week 4	AS-8	4/4/12 23:40	Off	Off
Week 4	AS-8	4/5/12 3:58	Off	Off
Week 5	AS-8	4/7/2012 1.:45	25	6.6
Week 7	AS-8	4/21/12 16:30	24	5.5
Week 7	AS-8	4/25/12 16:50	44	7.9
Week 8	AS-8	5/2/12 21:00	Off	Off
Week 10	AS-8	5/12/12 20:10	41	7.0
Week 11	AS-8	5/23/12 11:55	29	7.0
Week 12	AS-8	5/29/12 11:00	Off	Off
Week 16	AS-8	6/28/12 14:45	32	7.8
Week 18	AS-8	7/9/12 14:10	35	8.0
Week 18	AS-8	7/12/12 10:35	39	7.6
Week 20	AS-8	7/26/12 11:45	38	8.0
Week 20	AS-8	7/26/12 15:00	33	8.0
Week 21	AS-8	7/30/12 9:45	27	7.4
Week 22	AS-8	8/9/12 9:25	22	5.6
Week 23	AS-8	8/14/12 10:00	20	5.5
Week 26	AS-8	9/4/12 14:20	31	7.0
Week 28	AS-8	9/19/12 14:35	23	6.4
Week 28	AS-8	9/19/12 14:50	20	6.5
Week 28	AS-8	9/20/12 12:00	35	8.5
Week 29	AS-8	9/27/12 12:00	34	7.6
Week 30	AS-8	10/1/12 15:30	33	6.8
Week 30	AS-8	10/3/12 14:05	29	7.0
Week 32	AS-8	10/16/12 13:15	24	4.8
Week 33	AS-8	10/25/12 10:25	26	5.0
Week 34	AS-8	10/31/12 14:30	24	4.4
Week 36	AS-8	11/15/12 14:00	Off	Off

Table 2
Flowrate and Pressure Summary - Sparge Points
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Sparge Point	Date	Pressure (psi)
Main discharge Line	3/14/12 20:30	9.0
Main discharge Line	3/15/12 18:06	9.0
Main discharge Line	3/16/12 13:30	8.5
Main discharge Line	3/21/12 17:15	10.0
Main discharge Line	3/22/12 15:10	8.5
Main discharge Line	3/27/12 11:45	9.5
Main discharge Line	3/28/12 17:30	9.0
Main discharge Line	3/30/12 15:20	9.4
Main discharge Line	4/4/12 23:40	9.8
Main discharge Line	4/5/12 3:55	10.0
Main discharge Line	4/5/12 13:55	9.5
Main discharge Line	4/7/2012 1.:45	8.9
Main discharge Line	4/12/12 13:45	8.5
Main discharge Line	4/19/12 13:45	9.6
Main discharge Line	4/21/12 16:30	9.5
Main discharge Line	4/25/12 16:50	9.5
Main discharge Line	4/26/12 11:10	8.8
Main discharge Line	5/2/12 21:00	15.2
Main discharge Line	5/7/12 14:40	15.0
Main discharge Line	5/12/12 20:10	9.0
Main discharge Line	5/23/12 11:55	9.0
Main discharge Line	5/29/12 11:00	12.0
Main discharge Line	6/28/12 14:45	9.8
Main discharge Line	7/9/12 14:30	9.8
Main discharge Line	7/12/12 10:05	10.5
Main discharge Line	7/26/12 12:00	10.5
Main discharge Line	7/26/12 15:00	12.0
Main discharge Line	7/30/12 10:00	10.6
Main discharge Line	8/9/12 9:20	8.8
Main discharge Line	8/14/12 9:55	6.8
Main discharge Line	9/4/12 14:20	8.2
Main discharge Line	9/19/12 14:30	8
Main discharge Line	9/19/12 14:50	7
Main discharge Line	9/27/12 12:00	9.5
Main discharge Line	10/1/12 15:30	8.6
Main discharge Line	10/3/12 14:00	8.5
Main discharge Line	10/16/12 13:15	8.8
Main discharge Line	10/25/12 10:25	8.5
Main discharge Line	10/31/12 14:30	8.0
Main discharge Line	11/15/12 14:00	9.0

Table 3
Monitoring Point Pressure Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-1A	3/16/2012 13:40	OPEN	CLOSED	30.0
MP-1A	3/22/2012 14:40	OPEN	OPEN	45.0
MP-1A	3/30/2012 15:20	OPEN	CLOSED	38.0
MP-1A	4/5/2012 13:55	OPEN	CLOSED	36.0
MP-1A	4/12/2012 13:55	OPEN	OPEN	48.0
MP-1A	4/19/2012 13:50	OPEN	CLOSED	38.0
MP-1A	4/26/2012 11:15	OPEN	OPEN	56.0
MP-1A	5/7/2012 14:40	OPEN	CLOSED	20.0
MP-1A	5/14/2012 10:10	OPEN	OPEN	55.0
MP-1A	5/29/2012 14:15	OPEN	OPEN	74.0
MP-1A	6/8/2012 10:05	OPEN	OPEN	66.0
MP-1A	6/20/2012 12:30	OPEN	OPEN	0.34
MP-1A	6/20/2012 16:30	OPEN	CLOSED	0.1
MP-1A	7/9/2012 13:45	OPEN	OPEN	85.0
MP-1A	7/17/2012 10:10	CLOSED	OPEN	58.0
MP-1A	7/26/2012 11:20	CLOSED	OPEN	63.0
MP-1A	7/30/2012 10:30	CLOSED	OPEN	64.0
MP-1A	8/9/2012 9:40	CLOSED	OPEN	0.06
MP-1A	8/14/2012 10:05	CLOSED	OPEN	0.07
MP-1A	9/4/2012 14:45	CLOSED	OPEN	37.0
MP-1A	10/3/2012 14:15	CLOSED	OPEN	NM*
MP-1A	10/16/2012 13:30	CLOSED	OPEN	66

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-1B	3/16/2012 13:40	OPEN	CLOSED	26.0
MP-1B	3/22/2012 14:40	OPEN	OPEN	62.0
MP-1B	3/30/2012 15:20	OPEN	CLOSED	19.0
MP-1B	4/5/2012 13:55	OPEN	CLOSED	26.0
MP-1B	4/12/2012 13:55	OPEN	OPEN	58.0
MP-1B	4/19/2012 13:50	OPEN	CLOSED	67.0
MP-1B	4/26/2012 11:18	OPEN	OPEN	0.5
MP-1B	5/7/2012 14:40	OPEN	CLOSED	0.2
MP-1B	5/14/2012 10:10	OPEN	OPEN	NM*
MP-1B	5/29/2012 14:15	OPEN	OPEN	NM*
MP-1B	6/8/2012 10:05	OPEN	OPEN	NM*
MP-1B	6/20/2012 12:35	OPEN	OPEN	0.18
MP-1B	6/20/2012 16:30	OPEN	CLOSED	0.1
MP-1B	7/9/2012 13:45	OPEN	OPEN	NM*
MP-1B	7/17/2012 10:10	CLOSED	OPEN	NM*
MP-1B	7/26/2012 11:20	CLOSED	OPEN	NM*
MP-1B	7/30/2012 10:30	CLOSED	OPEN	100+
MP-1B	8/9/2012 9:40	CLOSED	OPEN	0.06
MP-1B	8/14/2012 10:05	CLOSED	OPEN	0.04
MP-1B	9/4/2012 14:45	CLOSED	OPEN	0.14
MP-1B	10/3/2012 14:15	CLOSED	OPEN	NM*
MP-1B	10/16/2012 13:30	CLOSED	OPEN	0

Table 3
Monitoring Point Pressure Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-1C	3/16/2012 13:40	OPEN	CLOSED	0.0
MP-1C	3/22/2012 14:40	OPEN	OPEN	36.0
MP-1C	3/30/2012 15:25	OPEN	CLOSED	0.0
MP-1C	4/5/2012 13:55	OPEN	CLOSED	0.0
MP-1C	4/12/2012 13:55	OPEN	OPEN	74.0
MP-1C	4/19/2012 13:50	OPEN	CLOSED	0.0
MP-1C	4/26/2012 11:18	OPEN	OPEN	NA
MP-1C	5/7/2012 14:40	OPEN	CLOSED	0.0
MP-1C	5/14/2012 10:10	OPEN	OPEN	NM*
MP-1C	5/29/2012 14:15	OPEN	OPEN	NM*
MP-1C	6/8/2012 10:05	OPEN	OPEN	NM*
MP-1C	6/20/2012 12:35	OPEN	OPEN	0.06
MP-1C	6/20/2012 16:30	OPEN	CLOSED	0.06
MP-1C	7/9/2012 13:45	OPEN	OPEN	NM*
MP-1C	7/17/2012 10:10	CLOSED	OPEN	NM*
MP-1C	7/26/2012 11:20	CLOSED	OPEN	NM*
MP-1C	7/30/2012 10:40	CLOSED	OPEN	100+
MP-1C	8/9/2012 9:40	CLOSED	OPEN	0.04
MP-1C	8/14/2012 10:05	CLOSED	OPEN	0.14
MP-1C	9/4/2012 14:45	CLOSED	OPEN	0.06
MP-1C	10/3/2012 14:15	CLOSED	OPEN	NM*
MP-1C	10/16/2012 13:30	CLOSED	OPEN	100+

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-2A	3/16/2012 13:50	OPEN	CLOSED	0.0
MP-2A	3/22/2012 14:50	OPEN	OPEN	0.25
MP-2A	3/30/2012 15:25	OPEN	CLOSED	>0.0
MP-2A	4/5/2012 14:05	OPEN	CLOSED	0.0
MP-2A	4/12/2012 14:00	OPEN	OPEN	0.0
MP-2A	4/19/2012 14:00	OPEN	CLOSED	0.5
MP-2A	4/26/2012 11:20	OPEN	OPEN	0.1
MP-2A	5/7/2012 14:50	OPEN	CLOSED	0.05
MP-2A	5/14/2012 10:15	OPEN	OPEN	0.0
MP-2A	5/29/2012 14:20	OPEN	OPEN	0.1
MP-2A	6/8/2012 10:10	OPEN	OPEN	0.1
MP-2A	6/20/2012 12:45	OPEN	OPEN	0.0
MP-2A	6/20/2012 16:35	OPEN	CLOSED	0.24
MP-2A	7/9/2012 13:50	OPEN	OPEN	0.1
MP-2A	7/17/2012 10:20	CLOSED	OPEN	0.0
MP-2A	7/26/2012 11:30	CLOSED	OPEN	0.17
MP-2A	7/30/2012 10:40	CLOSED	OPEN	0.00
MP-2A	8/9/2012 9:45	CLOSED	OPEN	0.08
MP-2A	8/14/2012 10:10	CLOSED	OPEN	0.10
MP-2A	9/4/2012 14:45	CLOSED	OPEN	0.02
MP-2A	10/3/2012 14:15	CLOSED	OPEN	0.10
MP-2A	10/16/2012 13:30	CLOSED	OPEN	0

Table 3
Monitoring Point Pressure Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-2B	3/16/2012 13:50	OPEN	CLOSED	0.0
MP-2B	3/22/2012 14:50	OPEN	OPEN	0.0
MP-2B	3/30/2012 15:25	OPEN	CLOSED	0.0
MP-2B	4/5/2012 14:05	OPEN	CLOSED	0.0
MP-2B	4/12/2012 14:00	OPEN	OPEN	0.0
MP-2B	4/19/2012 14:00	OPEN	CLOSED	0.5
MP-2B	4/26/2012 11:20	OPEN	OPEN	0.1
MP-2B	5/7/2012 14:50	OPEN	CLOSED	0.0
MP-2B	5/14/2012 10:15	OPEN	OPEN	76.0
MP-2B	5/29/2012 14:20	OPEN	OPEN	100+
MP-2B	6/8/2012 10:10	OPEN	OPEN	NM*
MP-2B	6/20/2012 12:45	OPEN	OPEN	0.0
MP-2B	6/20/2012 16:35	OPEN	CLOSED	0.07
MP-2B	7/9/2012 13:50	OPEN	OPEN	NM*
MP-2B	7/17/2012 10:20	CLOSED	OPEN	NM*
MP-2B	7/26/2012 11:30	CLOSED	OPEN	NM*
MP-2B	7/30/2012 10:40	CLOSED	OPEN	0.3
MP-2B	8/9/2012 9:45	CLOSED	OPEN	0.26
MP-2B	8/14/2012 10:10	CLOSED	OPEN	0.07
MP-2B	9/4/2012 14:45	CLOSED	OPEN	0.06
MP-2B	10/3/2012 14:15	CLOSED	OPEN	NM*
MP-2B	10/16/2012 13:30	CLOSED	OPEN	0

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-2C	3/16/2012 13:50	OPEN	CLOSED	12.0
MP-2C	3/22/2012 14:50	OPEN	OPEN	80.0
MP-2C	3/30/2012 15:25	OPEN	CLOSED	36.0
MP-2C	4/5/2012 14:05	OPEN	CLOSED	26.0
MP-2C	4/12/2012 14:00	OPEN	OPEN	50.0
MP-2C	4/19/2012 14:00	OPEN	CLOSED	1.5
MP-2C	4/26/2012 11:20	OPEN	OPEN	0.2
MP-2C	5/7/2012 14:50	OPEN	CLOSED	0.05
MP-2C	5/14/2012 10:15	OPEN	OPEN	0.22
MP-2C	5/29/2012 14:20	OPEN	OPEN	NM*
MP-2C	6/8/2012 10:10	OPEN	OPEN	0.15
MP-2C	6/20/2012 12:45	OPEN	OPEN	0.2
MP-2C	6/20/2012 16:35	OPEN	CLOSED	0.22
MP-2C	7/9/2012 13:50	OPEN	OPEN	NM*
MP-2C	7/17/2012 10:20	CLOSED	OPEN	0.05
MP-2C	7/26/2012 0:00	CLOSED	OPEN	100+
MP-2C	7/30/2012 10:40	CLOSED	OPEN	0.30
MP-2C	8/9/2012 9:45	CLOSED	OPEN	0.0
MP-2C	8/14/2012 10:10	CLOSED	OPEN	0.02
MP-2C	9/4/2012 14:45	CLOSED	OPEN	0.10
MP-2C	10/3/2012 14:15	CLOSED	OPEN	NM*
MP-2C	10/16/2012 13:30	CLOSED	OPEN	0

Table 3
Monitoring Point Pressure Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-2D	3/16/2012 13:50	OPEN	CLOSED	18.0
MP-2D	3/22/2012 14:50	OPEN	OPEN	17.0
MP-2D	3/30/2012 15:30	OPEN	CLOSED	25.0
MP-2D	4/5/2012 14:10	OPEN	CLOSED	31.0
MP-2D	4/12/2012 14:00	OPEN	OPEN	27.0
MP-2D	4/19/2012 14:00	OPEN	CLOSED	23.0
MP-2D	4/26/2012 11:20	OPEN	OPEN	9.0
MP-2D	5/7/2012 14:50	OPEN	CLOSED	16.0
MP-2D	5/14/2012 10:15	OPEN	OPEN	16.0
MP-2D	5/29/2012 14:20	OPEN	OPEN	9.5
MP-2D	6/8/2012 10:10	OPEN	OPEN	10.0
MP-2D	6/20/2012 12:45	OPEN	OPEN	2.0
MP-2D	6/20/2012 16:35	OPEN	CLOSED	6.5
MP-2D	7/9/2012 13:50	OPEN	OPEN	10.0
MP-2D	7/17/2012 10:20	CLOSED	OPEN	18.0
MP-2D	7/26/2012 10:30	CLOSED	OPEN	24.0
MP-2D	7/30/2012 10:40	CLOSED	OPEN	2.4
MP-2D	8/9/2012 9:45	CLOSED	OPEN	0.1
MP-2D	8/14/2012 10:10	CLOSED	OPEN	0.08
MP-2D	9/4/2012 14:45	CLOSED	OPEN	0.28
MP-2D	10/3/2012 14:15	CLOSED	OPEN	5.0
MP-2D	10/16/2012 13:30	CLOSED	OPEN	0.40

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-3A	3/16/2012 14:00	OPEN	CLOSED	36
MP-3A	3/22/2012 15:00	OPEN	OPEN	41
MP-3A	3/30/2012 15:30	OPEN	CLOSED	39
MP-3A	4/5/2012 14:10	OPEN	CLOSED	40
MP-3A	4/12/2012 14:05	OPEN	OPEN	44
MP-3A	4/19/2012 14:10	OPEN	CLOSED	42
MP-3A	4/26/2012 11:30	OPEN	OPEN	41
MP-3A	5/7/2012 15:00	OPEN	CLOSED	30
MP-3A	5/14/2012 10:20	OPEN	OPEN	40
MP-3A	5/29/2012 14:30	OPEN	OPEN	2.2
MP-3A	6/8/2012 10:20	OPEN	OPEN	42
MP-3A	6/20/2012 12:55	OPEN	OPEN	1.3
MP-3A	6/20/2012 16:40	OPEN	CLOSED	1.6
MP-3A	7/9/2012 14:00	OPEN	OPEN	2.0
MP-3A	7/17/2012 10:30	CLOSED	OPEN	52
MP-3A	7/26/2012 11:40	CLOSED	OPEN	56
MP-3A	7/30/2012 10:50	CLOSED	OPEN	1.5
MP-3A	8/9/2012 9:50	CLOSED	OPEN	0.0
MP-3A	8/14/2012 10:15	CLOSED	OPEN	0.02
MP-3A	9/4/2012 14:45	CLOSED	OPEN	0.17
MP-3A	10/3/2012 14:15	CLOSED	OPEN	43
MP-3A	10/16/2012 13:30	CLOSED	OPEN	0.88

Table 3
Monitoring Point Pressure Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-3B	3/16/2012 14:00	OPEN	CLOSED	0.02
MP-3B	3/22/2012 15:00	OPEN	OPEN	0.0
MP-3B	3/30/2012 15:30	OPEN	CLOSED	0.0
MP-3B	4/5/2012 14:10	OPEN	CLOSED	0.10
MP-3B	4/12/2012 14:05	OPEN	OPEN	0.0
MP-3B	4/19/2012 14:10	OPEN	CLOSED	0.4
MP-3B	4/26/2012 11:30	OPEN	OPEN	0.0
MP-3B	5/7/2012 15:00	OPEN	CLOSED	0.0
MP-3B	5/14/2012 10:20	OPEN	OPEN	0.0
MP-3B	5/29/2012 14:30	OPEN	OPEN	NM*
MP-3B	6/8/2012 10:20	OPEN	OPEN	0.1
MP-3B	6/20/2012 12:55	OPEN	OPEN	0.0
MP-3B	6/20/2012 16:40	OPEN	CLOSED	0.0
MP-3B	7/9/2012 14:00	OPEN	OPEN	0.0
MP-3B	7/17/2012 10:30	CLOSED	OPEN	0.05
MP-3B	7/26/2012 11:40	CLOSED	OPEN	0.22
MP-3B	7/30/2012 10:50	CLOSED	OPEN	0.0
MP-3B	8/9/2012 9:50	CLOSED	OPEN	0.1
MP-3B	8/14/2012 10:15	CLOSED	OPEN	0.11
MP-3B	9/4/2012 14:45	CLOSED	OPEN	0.05
MP-3B	10/3/2012 14:15	CLOSED	OPEN	0.0
MP-3B	10/16/2012 13:30	CLOSED	OPEN	0

Monitoring Point	Date	North Line Status (MOV-05880)	South Line Status (MOV-05881)	Pressure (inches H2O)
MP-3C	3/16/2012 14:00	OPEN	CLOSED	12.0
MP-3C	3/22/2012 15:00	OPEN	OPEN	14.0
MP-3C	3/30/2012 15:35	OPEN	CLOSED	8.3
MP-3C	4/5/2012 14:15	OPEN	CLOSED	7.5
MP-3C	4/12/2012 14:05	OPEN	OPEN	10.0
MP-3C	4/19/2012 14:10	OPEN	CLOSED	4.5
MP-3C	4/26/2012 11:30	OPEN	OPEN	3.0
MP-3C	5/7/2012 15:00	OPEN	CLOSED	2.5
MP-3C	5/14/2012 0:00	OPEN	OPEN	4.4
MP-3C	5/29/2012 14:30	OPEN	OPEN	4.3
MP-3C	6/8/2012 10:20	OPEN	OPEN	5.2
MP-3C	6/20/2012 12:55	OPEN	OPEN	2.4
MP-3C	6/20/2012 16:40	OPEN	CLOSED	2.3
MP-3C	7/9/2012 14:00	OPEN	OPEN	4.1
MP-3C	7/17/2012 10:30	CLOSED	OPEN	5.6
MP-3C	7/26/2012 11:40	CLOSED	OPEN	6.4
MP-3C	7/30/2012 10:50	CLOSED	OPEN	2.6
MP-3C	8/9/2012 9:50	CLOSED	OPEN	0.04
MP-3C	8/14/2012 10:15	CLOSED	OPEN	0.06
MP-3C	9/4/2012 14:45	CLOSED	OPEN	0.24
MP-3C	10/3/2012 14:15	CLOSED	OPEN	3.20
MP-3C	10/16/2012 13:30	CLOSED	OPEN	0

Notes: NM* = Not Measured due to active venting with water present

Table 4
Analytical Data and Field Data Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

AS-MW-1	Lab Data						Field Data					
	Sulfolane (ug/L)	Fe (ug/L)	Mn (ug/L)	TOC (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	Temp. (°C)	ORP (mV)	pH	Conductivity (µS/cm)	Water Elevation (ft)
Background (2/18)	71.7	624	4,160	3.66	<1.62 B*	0.00424 J	0.15	2.9	91	7	259.7	
Week 1 (3/14)	60.9	<156	3,460	2.95	<1.00 B*	<0.620	9.8	2.8	191.7	7.5	266.1	
Week 1 (3/14) - Duplicate	59.4						9.8	2.8	191.7	7.5	266.1	
Week 2 (3/21)	55.8	128 J	3,220	2.84	0.424 J	<0.620	12.69	2.7	187.6	7.5	221.3	
Week 3 (3/28)	33.9	<156	2,760	2.42	0.441 J	<0.00620	12.33	2.9	140	7.53	251.5	
Week 4 (4/4)	23.5	<156	2510	2.36	<0.0620	<0.620	13.38	2.7	443.8	7.56	245.6	482.53
Week 5 (4/11)	10.2 J	<156	2,540	2.54	<0.620	0.00690 J	14.05	2.7	341.6	7.8	227.4	482.61
Week 6 (4/18)	7.69 J	<156	2,380	2.75	<0.620	<0.00620	13.74	2.7	197	7.42	237.5	483.13
Week 7 (4/25)	3.70 J	<156	2,100	2.03	<1.00 B*	<0.00620	14.29	2.9	161.3	7.53	259.1	483.49
Week 8 (5/2)	<6.60	<156	1,870	2.22	<0.453 JL*	<0.0116 B*	15.2	2.56	239.1	5.28	224	483.12
Week 9 (5/11)	<6.66	<156	1,730	2.08	<1.00 B*	<0.0100 B*	15.77	2.5	336.1	8.50 *	207.9	483.18
Week 10 (5/18)	<6.52	<156	1,670	2.36	<1.00 B*	0.0106	12.83	2.6	87.8	7.77	224.1	482.79
Week 11 (5/25)	<6.66	<156	1,270	2.1	0.360 J	<0.00620	16.61	2.5	90.5	7.67	219.4	482.75
Week 12 (6/1)	<6.20	<156	729	1.97	<1.00 B*	<0.00620	16.9	2.3	75.5	7.68	222.5	483.36
Week 12 (6/1) - Duplicate	<6.20	<156	758	2.1	<1.00 B*	<0.0124	16.9	2.3	75.5	7.68	222.5	483.36
Week 13 (6/8)	<6.20	<156	262	1.9	0.317 J	<0.00620	14.25	3.1	160.2	7.64	163.7	483.18
Week 14 (6/15)	<6.46	<156	102	2.12	<0.480 B*	<0.0113 B*	17.48	2.3	188.6	7.14	223.2	484.03
Week 15 (6/22)	<6.20	<156 J*	23.8 JL*	1.96 JL*	<0.649 B*	0.00620 JL*	15.15	1.9	142.7	7.49	221.5	484.01
Week 16 (6/29)	<6.40	<156	2.67	2.12	<1.00 B*	0.0119	14.98	2.4	269.8	7.73	181.6	484.29
Week 17 (7/6)	<6.46	<156	1.60	2.31	<1.00 B*	0.122	16.05	2.0	173.0	7.56	214.6	485.05
Week 18 (7/13)	<6.20	<156	1.80	2.27	<0.837 B*	0.00329 J	13.64	2.0	111.5	7.31	218.5	484.60
Week 19 (7/20)	<6.32	<156	3.14	2.36	0.337 J	0.00927 J	9.29	2.4	150.3	7.15	223.4	484.64
Week 20 (7/27)	<6.26	<156	2.86	2.00	1.08	<0.00620	7.32	2.5	115.7	6.76	229.3	485.07
Week 21 (8/3)	<6.40	<156	4.57	2.02	<0.458 B*	0.0105	5.14	2.6	230.3	7.15	256.9	484.92
Week 22 (8/10)	7.87 J	<156	15.3	1.92	<0.620	0.00705 J	4.99	2.1	132.4	7.1	261.7	484.64
Week 23 (8/17)	11.7	<156	98.1	1.96	0.371 J	0.0142 B*	2.29	2.5	152.5	7.29	239.2	484.43
Week 25 (8/31)	20.3	<156	466	1.97	0.650 J	0.0871	0.77	2.7	100.7	6.89	239.7	484.29
Week 27 (9/14)	11.6	<156	569	2.67	<0.620	0.00412 J	0.99	2.5	160.1	7.09	208.5	483.87
Week 29 (9/28)	<6.20	86.5 J	288	1.65	<1.00 B*	0.00892 J	2.7	3.0	177.5	6.82	280.7	486.04
Week 31 (10/12)	<6.52	<156	5.8	2.07	<1.00 B*	0.00855 J	6.87	3.8	128.3	6.58	243.7	485.08
Week 33 (10/26)	<6.20	<156	2.22	2.06	<1.00 B*	0.00948 J	11.41	4.4	220.5	7	239.7	485.49
Week 35 (11/9)	<6.40	<156	1.71	2.04	<0.620	0.0162	7.43	3.7	140.9	6.86	228.4	485.43
Week 37 (11/20)	<6.60 J*	<156	1.25	1.92	0.429 J*	0.00548 J	6.74	4.2	184.2	6.92	249.7	485.53

Table 4
Analytical Data and Field Data Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

AS-MW-2	Lab Data						Field Data					
	Sulfolane (ug/L)	Fe (ug/L)	Mn (ug/L)	TOC (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	Temp. (°C)	ORP (mV)	pH	Conductivity (µS/cm)	Water Elevation (ft)
Background (2/18)	142	360	5,140	2.48	<1.03 B*	0.00818 J	0.35	3.1	81.2	7	267.3	
Week 1 (3/14)	27.8	<156	2,950	5.73	<1.00 B*	<0.620	11.02	3.1	169.4	7.88	240.9	
Week 2 (3/21)	24.3	<156	2,920	5.59	0.507 J	<0.620	14.21	3.1	157.1	7.82	201.8	
Week 3 (3/28)	4.48 J	<156	2,620	5.09	0.507 J	0.0405	13.83	3.2	137.1	7.74	226.7	
Week 3 (3/28) - Duplicate	6.79 J	<156	2,430	5.03	0.498 J	0.0472	13.83	3.2	137.1	7.74	226.7	
Week 4 (4/4)	<6.20	<156	2200	4.43	0.586 J	0.0105 J*	15.42	3.2	397	7.8	218.9	482.85
Week 5 (4/11)	<6.74	<156	2,010	4.11	0.449 J	0.0231	16.09	3.4	382.7	8.52	200.7	482.83
Week 6 (4/18)	<6.20	<156	1,880	3.89	0.370 J	0.00592 J	14.87	3.4	183.4	7.45	211.9	483.34
Week 7 (4/25)	<6.20	<156	1,650	3.54	<1.00 B*	0.00739 J	15.13	3.6	130	7.43	238.5	483.67
Week 8 (5/2)	<6.66	<156	1,270	3.64	0.710 J	<0.0117 B*	15.07	3.45	201.6	6.11	199	483.14
Week 9 (5/11)	<6.60	<156	1,130	3.23	<1.00 B*	<0.0100 B*	15.84	3.9	383.2	8.33 *	198.4	483.16
Week 10 (5/18)	<6.40	<156	825	3.18	<1.00 B*	0.0398	13.29	4.0	94.7	7.75	210.9	482.9
Week 11 (5/25)	<6.40	<156	545	3.08	<0.620	<0.00620	15.71	3.8	132.5	7.68	206.7	483.05
Week 11 (5/25) -Duplicate	<6.52	<156	562	2.9	0.848 J	<0.00620	15.71	3.8	132.5	7.68	206.7	483.05
Week 12 (6/1)	<6.52	<156	362	2.85	<1.00 B*	<0.00620	17.17	3.8	105.2	7.59	219.4	483.35
Week 13 (6/8)	<6.74	<156	151	2.83	<0.620	0.0204	13.82	3.9	117.7	7.70	184.9	483.78
Week 14 (6/15)	<6.20	<156	108	2.86	<1.26 B*	<0.0117 B*	17.76	3.9	180.4	7.28	221.1	483.98
Week 15 (6/22)	<6.20	<156 J*	14.5 JL*	2.75	<0.585 B*	0.00757 J	15.22	3.6	127.8	7.55	213.5	483.87
Week 16 (6/29)	<6.20	<156	30.9	2.94	<1.00 B*	0.00596 J*	14.89	4.1	288.4	7.66	182.7	484.23
Week 16 (6/29) -Duplicate	<6.20	<156	32.9	2.83	<1.00 B*	0.0133 J*	14.89	4.1	288.4	7.66	182.7	484.23
Week 17 (7/6)	<6.82	<156	24.5	2.98	<1.00 B*	0.0193	16.33	3.9	160.6	7.65	214.8	484.94
Week 18 (7/13)	<6.46	<156	3.20	3.01	<0.993 B*	0.00483 J	14.77	4.0	124.9	7.59	219.6	484.50
Week 19 (7/20)	<6.20	<156	0.580 J	3.15	0.738 J	0.0101	12.7	4.3	186.7	7.48	227.3	484.41
Week 20 (7/27)	<6.26	<156	1.46	2.95	1.37	0.00436 J	12.27	5.2	72.1	7.27	247.6	484.97
Week 21 (8/3)	<6.20	<156	3.30	2.31	<0.685 B*	0.0109	8.66	4.5	203.2	7.39	269.3	484.91
Week 22 (8/10)	<6.20	98.6 J	33.3	2.59	<1.00 B*	0.00833 J	8.61	4.3	137.1	7.31	275	484.62
Week 23 (8/17)	<6.32	86.2 J	36.2	2.67	<0.620	0.0115 B*	5.53	4.9	135.3	7.48	255	484.43
Week 25 (8/31)	<6.32	<156	52.1	2.61	<0.620	0.0120	3.26	5.3	96.4	7.21	264.1	484.26
Week 27 (9/14)	<6.20	96.2 J	29.2	2.99	0.449 J	0.919	3.21	5.0	152.8	7.51	214.5	483.88
Week 29 (9/28)	<6.20	128 J	19.2	1.92	<1.00 B*	0.0172	3.99	5.1	167.6	7.20	315.7	484.92
Week 31 (10/12)	<6.60	<156	5.87	2.67	<0.620	0.0158	7.9	5.5	109.6	6.95	285.44	484.60
Week 33 (10/26)	<6.20	<156	1.3	2.9	<1.00 B*	0.00785 J	11.16	5.3	313.8	7.17	249	484.04
Week 35 (11/9)	<6.32	167 J	17	2.61	0.756 J	0.0417	8.66	5.1	150.1	6.78	317.2	484.83
Week 37 (11/20)	<6.20 J*	<156 J*	3.12 J*	2.65 J*	0.459 J	<0.00620	10.45	4.2	107.9	7.18	77.9 [†]	484.99

Table 4
Analytical Data and Field Data Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

AS-MW-3	Lab Data						Field Data					
	Sulfolane (ug/L)	Fe (ug/L)	Mn (ug/L)	TOC (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	Temp. (°C)	ORP (mV)	pH	Conductivity (µS/cm)	Water Elevation (ft)
Background (2/18)	171	37100	5,900	10.2	<1.68 B*	0.0168	0.39	2.7	-37	6.69	627	
Week 1 (3/14)	159	29700	5,240	7.67	<1.00 B*	<0.620	0.24	2.5	-78.1	6.7	559	
Week 2 (3/21)	162	22000	5,110	8.08	0.978 J	<0.620	0.44	2.6	-30.8	6.75	444	
Week 3 (3/28)	147	19400	4,120	6.91	0.835 J	0.00787 J	0.25	2.8	-56.7	6.74	470.3	
Week 4 (4/4)	160	22300	4240	6.33	0.970 J	<0.00620	0.21	2.6	23.3	6.8	440.5	482.72
Week 5 (4/11)	125	17800	4,100	5.76	0.843 J	0.0201	0.26	2.6	27.8	7.39	395	482.75
Week 6 (4/18)	126	17200	4,490	5.76	0.719J	0.031	0.18	2.6	-20.2	6.57	398.3	483.16
Week 7 (4/25)	99.8	13600	4,160	5.22	<1.00 B*	0.011	0.11	2.7	-8.9	6.63	422.1	483.61
Week 8 (5/2)	73.8	3480	3,640	5.53	0.884 J	<0.0157 B*	0.56	2.35	73.8	6.69	358	483.05
Week 9 (5/11)	79.9	7820	3,250	5.31	<1.30 B*	<0.0176 B*	0.21	2.5	59.3	7.93 *	321.6	483.18
Week 10 (5/18)	71.8	5990	3,170	5.47	<1.17 B*	0.0302	0.49	2.5	-6.5	6.77	321.6	482.92
Week 11 (5/25)	72.1	3670	2,730	4.89	0.700 J	<0.00620	0.55	2.3	-16.8	6.73	301.1	483.00
Week 12 (6/1)	71.6	3470	2,330	4.63	<1.00 B*	0.00548 J	0.95	2.4	59.2	6.91	271.1	483.45
Week 13 (6/8)	25.6 J*	2770	2,080	4.95	0.866 J	0.0681	1.28	2.3	29.4	6.76	222.2	483.67
Week 14 (6/15)	18.7	1960	2,260	4.95	<1.78 B*	<0.0620 B*	1.51	2.5	41.1	6.72	242.0	483.16
Week 15 (6/22)	<6.20	1140 JL*	2,140 JL*	4.58 JL*	<1.12 B*	0.0130 JL*	0.78	2.0	22.8	6.70	228.2	484.15
Week 16 (6/29)	4.02 J	1490	2,300	4.43	<1.15 B*	0.00753 J	1.77	2.3	78.6	6.75	183.0	484.38
Week 17 (7/6)	<6.52	973	2,400	3.81	<1.00 B*	0.0103	2.91	1.9	68.1	6.73	206.6	484.86
Week 18 (7/13)	<6.20	<156	1,760	4.60	<0.881 B*	0.00539 J	7.26	1.9	154.1	6.71	219.7	484.38
Week 19 (7/20)	<6.20	<156	1,650	4.45	0.938 J	<0.00620	7.60	2.3	207	6.70	225.9	485.23
Week 20 (7/27)	<6.20	<156	2.03	3.39	1.63	0.00910 J	6.14	2.4	261.6	9.06	204.7	484.86
Week 21 (8/3)	<6.20	<156	2540	3.13	<1.30 B*	0.00800 J	2.94	2.2	137.7	6.62	232.1	484.95
Week 22 (8/10)	<6.32	115 J	2680	2.97	<1.00 B*	<0.00620	1.69	2.6	121.4	6.47	172.0	484.67
Week 23 (8/17)	<6.20	87.0 J	2740	2.79	0.619 J	0.0113 B*	1.32	2.8	102.7	6.56	212.5	484.46
Week 25 (8/31)	<6.20	249 J	2580	3.00	0.563 J	0.00787 J	0.34	3.3	88.8	6.62	210.0	484.30
Week 27 (9/14)	<6.20	212 J	2400	4.17	0.841 J	0.0332	0.56	3.9	68.0	6.81	238.0	483.88
Week 29 (9/28)	<6.52	205 J	2560	2.39	<1.00 B*	0.00554 J	0.70	4.2	139.5	6.50	243.2	485.07
Week 31 (10/12)	<6.20	125 J	1890	3.05	<1.00 B*	0.00525J	2.61	4.5	117.1	6.44	231.6	484.77
Week 33 (10/26)	<6.20	80 J	994	2.84	<1.00 B*	0.0802	5.51	4.7	210.7	6.38	242.1	484.19
Week 35 (11/9)	<6.20	234 J	619	2.6	1.01	0.0114	1.97	4.0	129.2	6.28	232.2	485.02
Week 37 (11/20)	<6.20 J*	237 J*	225 J*	2.55	0.601 J	0.168	2.48	3.7	126.1	6.54	73.8 ¹	485.07

Table 4
Analytical Data and Field Data Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

AS-MW-4	Lab Data						Field Data					
	Sulfolane (ug/L)	Fe (ug/L)	Mn (ug/L)	TOC (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	Temp. (°C)	ORP (mV)	pH	Conductivity (µS/cm)	Water Elevation (ft)
Background (2/18)	278	3850	7,160	5.6	<1.09 B*	<0.00620	0.31	2.6	28.2	6.76	386	
Week 1 (3/14)	199	302	4,230	5.99	<1.00 B*	<0.620	0.5	2.7	78.8	6.96	352.9	
Week 2 (3/21)	193	121 J	2,860	5.61	0.776 J	<0.620	1.15	2.7	108.2	7.02	259.5	
Week 3 (3/28)	153	<156	2,360	5.3	0.652 J	0.0323	0.82	2.9	101	7.03	292.4	
Week 4 (4/4)	139	98.1 J	2340	4.77	0.632 J	0.00705 J	0.82	2.8	262.4	7.22	289.1	482.51
Week 4 (4/4) - Duplicate	130	265	2500	4.3	0.559 J	0.0183	0.82	2.8	262.4	7.22	289.1	482.51
Week 5 (4/11)	123	124 J	2,170	4.79	0.535 J	0.0187	1.16	2.8	196.1	7.45	267.3	482.43
Week 6 (4/18)	148	202 J	2,470	4.3	0.366 J	0.02	0.72	2.8	66.8	6.87	289	483.13
Week 6 (4/18) - Duplicate	130	265	2,500	4.3	0.559 J	0.0183	0.72	2.8	66.8	6.87	289	483.13
Week 7 (4/25)	124	<156	2,300	4.67	<1.00 B*	0.0113	1.12	3	110.5	6.93	322.2	483.49
Week 8 (5/2)	87.3	<156	2,080	4.85	0.805 J	0.0417	2.46	2.57	170.7	5.59	277	482.86
Week 8 (5/2) - Duplicate	84.4	143 J	1,970	4.94	0.734 J	0.0372	2.46	2.57	170.7	5.59	277	482.86
Week 9 (5/11)	75.2	<156	1,790	5.01	<1.20 B*	<0.0144 B*	3.15	2.8	87.5	7.01 *	278.1	483.15
Week 10 (5/18)	59.1	<156	1,650	5.15	<1.10 B*	0.0247	3.1	2.7	79.3	7.14	288	482.82
Week 11 (5/25)	55	<156	1,470	5.19	0.312 J	0.01	4.15	2.6	109	7.02	288.8	482.91
Week 12 (6/1)	35.3	<156	1,270	4.78	<1.00 B*	<0.00620	5.07	2.7	113.2	6.91	327.8	483.3
Week 13 (6/8)	<6.40	<156	705	5.75	0.728 J	0.05	5.19	2.6	176.2	7.04	285	483.61
Week 14 (6/15)	22.0	<156	466	5.43	<1.42 B*	<0.00620 B*	6.25	2.7	181.2	6.68	353.0	484.18
Week 15 (6/22)	<6.20	<156 J*	134 JL*	5.20	<0.897 B*	0.0110 JL*	5.47	2.2	123.8	6.97	337.1	483.98
Week 16 (6/29)	15.7	<156	105	5.50	<1.00 B*	0.0563 J	4.66	2.6	269.7	6.98	292.9	484.28
Week 17 (7/6)	21.7	<156	188	4.95	<1.00 B*	0.0125	4.92	2.4	156.6	6.95	372.5	484.81
Week 18 (7/13)	<6.52	<156	12.9	5.42	<0.513 B*	0.00902 J	3.47	2.4	149.1	6.98	9.6	484.35
Week 19 (7/20)	<6.32	<156	11.3	5.57	0.900 J	0.0136	9.25	2.6	217.6	6.91	382.6	484.23
Week 20 (7/27)	3.61 J	<156	15.7	5.65	2.09	0.0157	4.52	5.3	82.7	6.83	501.0	484.88
Week 21 (8/3)	<6.40	105 J	203	5.26	<0.777 B*	0.0141	4.13	2.6	194.9	6.81	482.3	484.94
Week 22 (8/10)	<6.26	<156	142	5.28	<1.00 B*	0.0172	5.83	2.3	157.6	6.70	430.7	484.64
Week 23 (8/17)	<6.26	<156	139	5.30	0.499 J	0.0949 B*	4.14	3.1	159.3	6.82	409.5	484.46
Week 25 (8/31)	<6.32	<156	275	5.35	0.481 J	0.0218	2.25	3.6	129.2	6.68	413.8	484.28
Week 27 (9/14)	<6.20	169 J	112	5.38	0.663 J	0.023	2.07	3.6	156.1	6.78	302.0	483.88
Week 29 (9/28)	<6.20	<156	251	4.49	<1.00 B*	0.0176	2.11	3.8	174.2	6.65	453.7	485.36
Week 31 (10/12)	<6.20	<156	43	4.46	<1.00 B*	0.00935 J	6.57	4.3	121.9	6.44	365.0	485.1
Week 33 (10/26)	<6.20	1320	115	4.63	<1.00 B*	0.0725	9.8	4.4	332.3	6.66	337.1	484.46
Week 35 (11/9)	<6.20	<156	161	5.23	1.03	0.0206	4.36	4.2	141	6.52	475.7	485.3
Week 37 (11/20)	<6.74	89.5 J	72.4	4.65	0.613 J	0.0226	7.18	4.2	211.8	6.71	396.9	485.36

Table 4
Analytical Data and Field Data Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

AS-MW-5	Lab Data						Field Data					
	Sulfolane (ug/L)	Fe (ug/L)	Mn (ug/L)	TOC (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	Temp. (°C)	ORP (mV)	pH	Conductivity (µS/cm)	Water Elevation (ft)
Background (2/20)	125	966	4,890	2.52	<1.00 B*	0.0179	0.27	3.6	92.1	6.93	246.1	
Week 1 (3/14)	96.8	<156	3,630	3.99	<1.00 B*	<0.620	2.09	3.5	111.5	7.58	265.8	
Week 2 (3/21)	89.9	<156	3,480	4.01	0.728 J	<0.620	2.43	3.3	148	7.18	238	
Week 2 (3/21) - Duplicate	92	<156	3,540	3.96	1.20 J	<0.620	2.43	3.3	148	7.18	238	
Week 3 (3/28)	62.6	<156	2,700	3.75	0.485 J	0.0195	3.08	3.4	135.7	7.2	249.8	
Week 4 (4/4)	44.9	<156	2,420	3.73	0.641 J	0.0112 J*	3.31	3.5	399.1	7.15	257	482.16
Week 5 (4/11)	19.7	<156	2,220	3.94	0.514 J	0.0421	4.76	3.5	135.5	7.25	237.3	482.24
Week 6 (4/18)	17.1	<156	1,950	4.16	0.434 J	0.0282	6.01	3.5	197.1	6.99	258	482.65
Week 7 (4/25)	8.70 J	<156	1,790	4.14	<1.00 B*	0.00453 J	4.6	3.8	156.9	7.01	285.1	483
Week 8 (5/2)	5.24 J	<156	1,820	4.3	0.570 J	0.0482	8.8	3.45	101.6	6.94	255	483.18
Week 9 (5/11)	<6.52	234 J	1,420	4.73	<1.24 B*	0.0926	13.55	3.7	385.5	8.48 *	213.3	483.05
Week 10 (5/18)	<6.52	<156	712	4.87	<1.00 B*	0.269	11.26	3.6	126.1	7.24	292.3	482.84
Week 11 (5/25)	<6.74	<156	111	4.48	0.370 J	0.00638 J	12.98	3.5	96.4	7.14	295.8	483.04
Week 12 (6/1)	<6.52	<156	30	4.33	<1.00 B*	0.0177	15.46	3.5	163.5	7.06	307.3	482.82
Week 13 (6/8)	<6.60	<156	14	4.36	0.404 J	0.0459	12.77	3.5	131.6	7.22	260.5	483.77
Week 14 (6/15)	<6.52	<156	5.16	4.58	<1.23 B*	0.0220	13.05	3.5	251.9	7.10	316.1	483.64
Week 15 (6/22)	<6.20	<156 J*	3.92 JL*	5.72	<0.784 B*	0.0185 JL*	10.01	3.6	201.4	7.20	268.2	482.44
Week 16 (6/29)	<6.20 J*	<156	4.33	4.85	<1.00 B*	0.0334	13.24	3.1	146.4	7.21	284.7	483.99
Week 17 (7/6)	<6.74	<156	4.28	4.61	<1.00 B*	0.0272	13.51	3.6	239.2	7.19	332.2	484.76
Week 18 (7/13)	<6.20	<156	5.43	4.69	<0.980 B*	0.0132	15.40	3.6	191.7	7.33	322.7	483.90
Week 19 (7/20)	<6.20	<156	2.98	4.75	0.798 J	0.0139	15.65	3.9	303.1	7.46	311.4	483.55
Week 20 (7/27)	<6.20	<156	24.9	3.92	1.56	0.00663 J	13.65	3.7	317.1	8.39	277.7	484.66
Week 21 (8/3)	<6.20	95.6 J	20.5	3.13	<0.575 B*	0.00774 J	11.04	3.5	102.8	7.25	291.7	484.92
Week 22 (8/10)	<6.20	<156	18.6	3.09	<1.00 B*	0.0219	8.88	3.7	112.0	7.20	281.8	484.64
Week 23 (8/17)	<6.26	<156	14.1	2.96	0.325 J	0.0114 B*	5.63	4	106.1	7.02	298.1	484.48
Week 25 (8/31)	<6.32	<156	26.8	3.62	<0.620	0.0112	2.78	4.7	120.8	7.48	283.9	484.26
Week 27 (9/14)	<6.20	<156	45.3	3.22	0.478 J	0.00876 J	2.22	5.0	127.4	7.61	296.2	483.87
Week 29 (9/28)	<6.20	<156	48.5	2.08	<1.00 B*	0.0219	4.34	5.4	128.7	6.94	307.4	485.35
Week 31 (10/12)	<6.20	301	63.5	3.5	<1.00 B*	0.0206	13.01	5.8	83.9	7.46	375.4	484.89
Week 33 (10/26)	<6.20	<156	24.3	3.81	<1.00 B*	0.026	11.90	5.2	111.6	7.13	339.6	484.43
Week 35 (11/9)	<6.20	<156	20.7	2.82	0.756 J	0.0127	8.88	5.4	128.8	6.98	374	485.28
Week 37 (11/20)	<6.20	156 J*	29.7 J*	3.23	0.457 J	0.00750 J	13.78	5.4	256.5	7.26	355.9	485.32

Table 4
Analytical Data and Field Data Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

AS-MW-6	Lab Data						Field Data					
	Sulfolane (ug/L)	Fe (ug/L)	Mn (ug/L)	TOC (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	Temp. (°C)	ORP (mV)	pH	Conductivity (µS/cm)	Water Elevation (ft)
Background (2/20)	146	2210	3,920	2.39	<1.13 B*	0.154	0.23	3.6	-17.4	7.16	241.2	
Week 1 (3/14)	95.9	<156	3,130	5.67	<1.00 B*	<0.620	2.08	3.5	108.2	7.36	288.1	
Week 2 (3/21)	80.2	<156	3,060	5.54	0.633 J	<0.620	2.42	3.3	138.4	7.15	257.4	
Week 3 (3/28)	60.8	<156	2,810	5.26	0.477 J	0.0146 J	0.99	3.4	127.1	7.24	269.9	
Week 4 (4/4)	56.1	<156	2790	5.34	0.648 J	0.0100 J*	3.31	3.5	395.8	7.24	272.7	481.91
Week 5 (4/11)	43	<156	3,140	5.33	0.541 J	0.0365	2.66	3.5	137.8	7.32	247.6	482.32
Week 6 (4/18)	51.6	<156	3,280	5.34	0.479 J	0.107	4.21	3.5	187.8	7.06	265.5	482.66
Week 7 (4/25)	30.4	<156	2,960	5.62	<1.00 B*	0.226 J*	4.65	3.5	139.3	7.1	227.5	483.09
Week 7 (4/25) - Duplicate	30.2	<156	3,040	5.82	<1.51 B*	0.952 J*	4.65	3.5	139.3	7.1	227.5	483.09
Week 8 (5/2)	26.3	<156	3,030	6.08	0.821 J	0.0695	6.27	3.27	84.1	6.28	273	483.05
Week 9 (5/11)	21.1	<156	3,390	6.29	<1.22 B*	0.0686	9.56	3.6	373	9.77 *	283	483.01
Week 10 (5/18)	<6.46	<156	3,680	6.98	<1.09 B*	0.476 J*	11.76	3.4	86.1	7.48	306.6	482.63
Week 10 (5/18) - Duplicate	4.31 J	<156	3,470	6.56	<1.00 B*	0.645 J*	11.76	3.4	86.1	7.48	306.6	482.63
Week 11 (5/25)	<6.52	<156	3,790	5.69	0.320 J	0.22	12.61	3.3	109	7.37	348	482.94
Week 12 (6/1)	<6.82	<156	3,380	5.17	<1.00 B*	0.0836	15.6	3.4	181.1	7.51	364.4	482.97
Week 13 (6/8)	<6.46	<156	3,470	4.9	0.519 J	0.174	12.97	3.5	147.2	7.48	330.4	483.68
Week 14 (6/15)	<6.20	<156	3,150	4.48	<1.47 B*	0.0781	13.42	3.3	244.8	7.34	377.8	483.7
Week 14 (6/15) - Duplicate	<6.52	<156	3,510	4.42	2.99	0.0599	13.42	3.3	244.8	7.34	377.8	483.7
Week 15 (6/22)	<6.20	<156 J*	2,800 JL*	4.70	<1.54 B*	0.110	9.36	3.3	203.0	7.32	365.4	483.68
Week 15 (6/22) - Duplicate	<6.20	<156 J*	2,710 JL*	4.69	<1.26 B*	0.0153 JL*	9.36	3.3	203.0	7.32	365.4	483.68
Week 16 (6/29)	<6.20	<156	2,060	4.46	<1.00 B*	0.228	14.19	2.9	153.7	7.42	300.9	483.93
Week 17 (7/6)	<6.82	<156	1,510	4.24	<1.00 B*	0.0267 J*	13.94	3.2	240.1	7.44	311.0	484.67
Week 17 (7/6) - Duplicate	<6.40	<156	1,470	4.26	<1.00 B*	0.0142 J*	13.94	3.2	240.1	7.44	311.0	484.67
Week 18 (7/13)	<6.20	<156	1,050	4.16	<1.38 B*	0.0137	15.57	3.0	192.9	7.51	252.9	483.51
Week 18 (7/13) - Duplicate	<6.20	<156	1,010	4.28	<1.32 B*	0.00934 J	15.57	3.0	192.9	7.51	252.9	483.51
Week 19 (7/20)	<6.20 J*	<156	782	5.06	1.07	0.0215	14.5	3.3	303.3	7.53	268.4	483.2
Week 19 (7/20) - Duplicate	<6.20	<156	817	4.80	1.44	0.0176	14.5	3.3	303.3	7.53	268.4	483.2
Week 20 (7/27)	<6.20	<156	630	4.21	1.40	0.213	13.79	3.6	312.1	8.19	278.4	484.38
Week 21 (8/3)	<6.20	274	636	3.81	<0.865 B*	0.0287	11.49	3.8	108.1	7.22	380.0	484.94
Week 22 (8/10)	<6.32	<156	359	3.55	<1.00 B*	0.114	10.39	4.4	104.1	7.11	335.4	484.67
Week 23 (8/17)	<6.20	<156	161	3.47	1.30 B*	0.0208 B*	7.61	4.9	102.6	7.06	365.1	484.45
Week 25 (8/31)	<6.32	<156	121	4.68	0.354 J	0.0237	5.62	6.3	127.4	7.46	334.9	484.26
Week 27 (9/14)	<6.20	<156	134	4.11	0.369 J	0.0232	4.58	6.1	122.1	7.50	318.0	483.90
Week 29 (9/28)	<6.20	<156	113	3.06	<1.00 B*	0.00965 J	8.33	6.4	128.9	6.99	375.7	485.47
Week 31 (10/12)	<6.20	<156	10	4.94	<1.00 B*	0.00571 J	14.02	6.7	51.7	7.50	315.9	484.98
Week 33 (10/26)	<6.20	355	22	4.72	<1.00 B*	0.039	12.86	5.9	99.0	7.23	261.5	484.59
Week 35 (11/9)	<6.20	<156	7	4.23	0.623 J	0.0175	10.04	5.6	114.5	7.05	261.4	485.34
Week 37 (11/20)	<6.74	<156	4	4.45	0.777 J	0.00763 J	14.86	5.6	250.2	7.40	260.4	485.30

Table 4
Analytical Data and Field Data Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

AS-MW-7	Lab Data						Field Data					
	Sulfolane (ug/L)	Fe (ug/L)	Mn (ug/L)	TOC (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	Temp. (°C)	ORP (mV)	pH	Conductivity (µS/cm)	Water Elevation (ft)
Background (2/20)	143	2390	2,470	2.75	<1.00 B*	0.0459	0.15	3.2	-13.9	7.09	247.8	
Week 1 (3/14)	116	<156	1,420	4.81	<1.00 B*	<0.620	8.89	3.3	151.7	7.58	242.3	
Week 2 (3/21)	91.7	<156	1,360	4.67	0.674 J	<0.620	9.58	3.1	129.7	7.4	225.7	
Week 3 (3/28)	54.2	<156	1,080	4.81	0.633 J	0.0154	9.63	3.3	122.9	7.47	237.1	
Week 4 (4/4)	27.4	<156	1140	4.62	0.791 J	<0.00620	10.93	3.2	44.7	7.75	235.8	482.08
Week 5 (4/11)	9.95 J	<156	974	5.23	0.639 J	0.0158 J*	12.55	3.3	354	8.12	223.5	481.88
Week 5 (4/11) - Duplicate	10.6 J	<156	983	5.19	0.582 J	0.0226 J*	12.55	3.3	354	8.12	223.5	481.88
Week 6 (4/18)	<6.20	<156	1,020	5.32	0.552 J	0.00917 J	12.26	3.2	196.2	7.5	239.2	482.5
Week 7 (4/25)	<6.32	<156	917	5.05	<1.88 B*	0.00318 J	12.05	3.3	155.3	7.47	263.4	482.81
Week 8 (5/2)	<6.46	<156	785	4.92	0.978 J	<0.0151 B*	12.91	3.07	216	5.64	204	482.55
Week 9 (5/11)	<6.40	<156	664	4.64	<1.45 B*	<0.0145 B*	11.26	10.1	352.2	8.44 *	237.5	482.83
Week 10 (5/18)	<6.32	<156	657	4.89	<1.00 B*	0.00972 J	15.81	3.2	86.7	7.77	234.7	482.14
Week 11 (5/25)	<7.04	<156	564	3.97	<0.620	0.026	13.18	3.5	113.6	7.75	231.5	482.2
Week 12 (6/1)	<6.20	<156	448	3.65	<1.00 B*	0.00674 J	11.68	3	134.8	7.65	233.2	482.31
Week 13 (6/8)	<6.88	<156	405	3.59	0.387 J	0.0146	13.40	3.2	183.0	7.87	205.4	482.66
Week 13 (6/8) - Duplicate	<6.74	<156	429	3.69	1.34	0.0123	13.40	3.2	183.0	7.87	205.4	482.66
Week 14 (6/15)	<6.66	<156	294	3.55	<1.57 B*	0.0294	15.76	3.0	245.0	7.78	237.0	483.26
Week 15 (6/22)	<6.20	<156 J*	96.4 JI*	3.50	<0.698 B*	0.0122 JI*	13.86	2.9	178.3	7.73	233.2	483.26
Week 16 (6/29)	<6.20	<156	164	3.41	<1.00 B*	0.0135	14.90	2.6	101.1	7.79	223.8	483.88
Week 17 (7/6)	<6.32 J*	<156	105	3.19	<1.00 B*	0.00335 J	14.59	3.0	237.2	7.83	239.5	484.81
Week 18 (7/13)	<6.20	<156	129	3.21	<0.607 B*	0.00391 J	16.49	3.1	165.9	7.75	224.8	483.62
Week 19 (7/20)	<6.20	<156	21.3	3.20	0.933 J	0.00627 J	15.93	3.3	297.1	7.78	225.2	482.6
Week 20 (7/27)	<6.20	<156	12.7	2.76	1.29	0.00906 J	14.76	3.4	307.4	8.32	222.6	484.57
Week 21 (8/3)	<6.20	<156	7.54	2.87	<0.819 B*	0.00797 J	12.02	3.3	91.9	7.02	279.5	483.94
Week 22 (8/10)	<6.32	<156	6.36	2.85	<1.00 B*	0.0233	11.32	3.8	83.7	7.45	265.3	484.65
Week 23 (8/17)	<6.20	<156	11.5	2.85	7.49	<0.0100 B*	8.39	4.1	103.7	7.05	291.3	484.45
Week 25 (8/31)	<6.66	116 J	12.8	3.18	0.324 J	0.0171	8.75	4.7	140.1	7.68	271.3	484.11
Week 27 (9/14)	<6.20	147 J	6.20	3.07	0.922 J	0.0124	10.33	5.0	109.9	7.86	282.6	483.79
Week 29 (9/28)	<6.20	<156	4.74	2.32	<1.00 B*	0.0918	12.27	5.1	120.2	6.95	323.9	485.1
Week 31 (10/12)	<6.20	190 J	12.4	3.03	<1.00 B*	0.022	15.22	5.0	55.4	7.93	314.5	484.33
Week 33 (10/26)	<6.20	162 J	7.21	3.14	<1.00 B*	0.0173	13.56	4.6	72.5	7.63	272.6	483.68
Week 35 (11/9)	<6.20	<156	0.959 J	3.06	0.313 J	0.0167	13.68	4.8	100.8	7.49	301.9	485.11
Week 37 (11/20)	<6.46	156 J*	0.778 J*	3.12	0.396 J	0.00464 J	13.94	4.3	140.8	7.69	271.6	485.23

Table 4
Analytical Data and Field Data Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

AS-MW-8	Lab Data						Field Data					
	Sulfolane (ug/L)	Fe (ug/L)	Mn (ug/L)	TOC (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	DO (mg/L)	Temp. (°C)	ORP (mV)	pH	Conductivity (µS/cm)	Water Elevation (ft)
Background (2/20)	146	2600	3,850	2.56	<1.00 B*	0.00544 J	0.16	3.6	-43.3	7.18	255.1	
Week 1 (3/14)	150	340	3,990	2.77	<1.00 B*	<0.620	0.35	3.4	76.8	7.15	301.7	
Week 2 (3/21)	145	327	3,780	3.19	0.606 J	<0.620	0.46	3.2	21.7	7.06	258.9	
Week 3 (3/28)	150	199 J	3,520	2.46	0.463 J	0.0111	0.25	3.3	17.7	7.24	263.5	
Week 4 (4/4)	143	536	3,540	2.41	0.348 J	<0.00620	0.19	3.3	-2.7	7.27	243.6	483.05
Week 5 (4/11)	133	88.9 J	2,940	2.92	0.357 J	0.0146	0.44	3.4	89	7.34	251.4	483.14
Week 6 (4/18)	112	<156	2,900	3.53	0.419 J	0.0189	0.2	3.4	76.5	7.06	275.5	483.68
Week 7 (4/25)	9.55 J	<156	6,440	7.82	<1.76 B*	0.0954	4.98	2.9	80.9	6.99	280.4	484.04
Week 8 (5/2)	30.5	<156	901	6.38	0.880 J	<0.0144 B*	0.67	2.97	103.7	6.51	255	483.66
Week 9 (5/11)	72.4	<156	1,190	3.79	<1.15 B*	<0.0146 B*	0.15	3.3	58.5	7.05 *	243.6	483.37
Week 10 (5/18)	51.4	<156	1,750	3.01	<1.00 B*	0.00664 J	0.11	3.1	83.3	7.22	245.7	483.24
Week 11 (5/25)	70.4	<156	2,140	2.66	0.677 J	0.0532	0.11	2.9	111.7	7.17	235.1	483.34
Week 12 (6/1)	64.9	<156	1,590	4.05	<1.00 B*	<0.00620	1.16	3	35.5	7.31	279.9	483.87
Week 13 (6/8)	44.5	<156	1,740	4.55	1.08	<0.00620	1.45	3.1	142.2	7.14	257.9	484.06
Week 14 (6/15)	54.8	<156	1,680	4.50 J*	<1.54 B*	<0.0620 B*	1.33	2.9	85.7	7.09	300.0	484.60
Week 15 (6/22)	79.0	<156 J*	2,640 J*	3.05	<0.522 B*	<0.00620 J*	0.41	2.5	87.4	7.00	257.3	484.33
Week 16 (6/29)	48.1	<156	2,780	3.37	<1.00 B*	0.0109	0.59	2.6	153.6	7.10	263.0	484.74
Week 17 (7/6)	70.5	<156	2,640	2.54	<1.00 B*	0.00581 J	0.29	2.6	75.2	7.19	238.5	484.23
Week 18 (7/13)	55.1	<156	1,990	3.06	<1.17 B*	0.00594 J	0.44	3.0	207.8	7.07	270.0	484.76
Week 19 (7/20)	63.0	<156	1,420	3.10	1.59	0.00644 J	0.54	5.1	176.9	7.07	277.7	484.76
Week 20 (7/27)	60.2	<156	2,120	2.46	1.13	<0.00620	0.26	3.4	78.1	7.02	260.6	486.08
Week 20 (7/27) - Duplicate	54.7	<156	2,280	2.55	1.18	<0.00620	0.26	3.4	78.1	7.02	260.6	486.08
Week 21 (8/3)	85.5	<156	3,530	2.33	<0.886 B*	<0.00620	0.48	3.7	166.7	7.18	277.1	485.02
Week 21 (8/3) - Duplicate	86.6	<156	3,470	2.30	<0.638 B*	<0.00620	0.48	3.7	166.7	7.18	277.1	485.02
Week 22 (8/10)	93.0	<156	3,850	2.33	<1.00 B*	<0.00620	0.18	3.3	112.2	7.09	285.8	484.71
Week 22 (8/10) - Duplicate	87.1	<156	3,610	2.33	<1.00 B*	<0.00620	0.18	3.3	112.2	7.09	285.8	484.71
Week 23 (8/17)	85.0	<156	3,880	2.26	<1.00 B*	<0.0100 B*	0.08	4.1	66.4	6.99	268.5	484.55
Week 23 (8/17) - Duplicate	92.9	<156	3,830	2.37	<1.00 B*	<0.0100 B*	0.08	4.1	66.4	6.99	268.5	484.55
Week 25 (8/31)	89.5	<156	4,170	2.35	<0.620	<0.00620	0.07	4.5	69.6	7.25	253.6	484.37
Week 25 (8/31) - Duplicate	88.8	<156	4,260	2.37	0.453 J	<0.00620	0.07	4.5	69.6	7.25	253.6	484.37
Week 27 (9/14)	87.5	89.7 J	4,460	2.42	<0.620	0.00471 J	0.06	4.5	36.9	7.39	258.2	483.97
Week 27 (9/14) - Duplicate	86.0	78.1 J	4,440	2.5	0.329 J	<0.0062	0.06	4.5	36.9	7.39	258.2	483.97
Week 29 (9/28)	82.7	141 J	4,300	1.78	<1.00 B*	0.00739 J	0.15	4.2	47.9	7.04	312.3	485.24
Week 29 (9/28) - Duplicate	79.8	111 J	4,320	1.62	<1.00 B*	0.00778 J	0.15	4.2	47.9	7.04	312.3	485.24
Week 31 (10/12)	28.7	82.0 J	1,560	3.35	<1.00 B*	<0.00620	0.47	4.9	81.5	7.03	418.7	485
Week 31 (10/12) - Duplicate	31.9	116 J	1,550	3.25	<1.00 B*	<0.00620	0.47	4.9	81.5	7.03	418.7	485
Week 33 (10/26)	38.8 J*	<156	794	2.74	<1.00 B*	<0.00620	1.97	4.8	290	6.80	321.6	484.37
Week 33 (10/26) - Duplicate	38.6 J*	<156	798	2.92	<1.00 B*	<0.00620	1.97	4.8	290	6.80	321.6	484.37
Week 35 (11/9)	77.0	131 J	3,180	2.23	0.354 J	0.00762 J	0.22	4.2	18.5	6.98	257.3	485.24
Week 35 (11/9) - Duplicate	73.1	141 J	3,310	2.24	0.623 J	0.00700 J	0.22	4.2	18.5	6.98	257.3	485.24
Week 37 (11/20)	35.9 J*	207 J*	1,570 J*	2.29	0.417 J*	0.154 J*	0.44	3.9	42.6	7.06	77.5 ¹	485.29
Week 37 (11/20) - Duplicate	37.6 J*	214 J	1,470	2.26	0.554 J*	0.0186 J*	0.44	3.9	42.6	7.06	77.5 ¹	485.29

Notes:

- 1 Suspected meter malfunction, reading unreliable
- mg/L milligrams per liter
- * S&W applied flag
- J Estimated concentration below the limit of quantitation
- J* Estimated concentration, qualified due to elevated field-duplicate RPD
- J* (Week 13, 33) Estimated concentration, qualified due to sulfolane-d8 recovery failure
- J* (Week 15) Limit of detection flagged in question due to elevated sample temperature
- J* (Week 16, 17, 19, 21, 37) Limit of detection or result flagged due to QC failures
- JL* Estimated concentration, biased low, due to elevated sample temperature
- B*, B Analyte considered not detected at listed reporting level due to method-blank contamination

Table 5
Background Monitoring VOC Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

			AS-MW-8	AS-MW-8 (Duplicate)
Method	Analyte	Units		
EP200.8 (D)	Iron	ug/L	2600	--
EP200.8 (D)	Manganese	ug/L	3850	--
SM 5310B	Total Organic Carbon	mg/L	2.56	--
SM20 4500-N D	Total Kjeldahl Nitrogen	mg/L	< 1.00 B	--
SM21 4500P-B,E	Total Phosphorus	mg/L	0.00544J	--
Sulfolane-EPA1625B w/Iso Dil-W	Sulfolane	mg/L	0.146	--
Sulfolane-EPA1625B w/Iso Dil-W*	Sulfolane	mg/L	0.150	--
SW8260B	Benzene	ug/L	< 0.240	< 0.240
SW8260B	Toluene	ug/L	< 0.620	< 0.620
SW8260B	Ethylbenzene	ug/L	< 0.620	< 0.620
SW8260B	n-Butylbenzene	ug/L	< 0.620	< 0.620
SW8260B	Carbon disulfide	ug/L	< 1.24	< 1.24
SW8260B	1,4-Dichlorobenzene	ug/L	< 0.300	< 0.300
SW8260B	1,2-Dichloroethane	ug/L	< 0.300	< 0.300
SW8260B	1,3,5-Trimethylbenzene	ug/L	< 0.620	< 0.620
SW8260B	4-Chlorotoluene	ug/L	< 0.620	< 0.620
SW8260B	Chlorobenzene	ug/L	< 0.300	< 0.300
SW8260B	4-Methyl-2-pentanone (MIBK)	ug/L	< 6.20	< 6.20
SW8260B	cis-1,2-Dichloroethene	ug/L	< 0.620	< 0.620
SW8260B	4-Isopropyltoluene	ug/L	< 0.620	< 0.620
SW8260B	cis-1,3-Dichloropropene	ug/L	< 0.300	< 0.300
SW8260B	n-Propylbenzene	ug/L	< 0.620	< 0.620
SW8260B	Styrene	ug/L	< 0.620	< 0.620
SW8260B	Dibromomethane	ug/L	< 0.620	< 0.620
SW8260B	trans-1,3-Dichloropropene	ug/L	< 0.620	< 0.620
SW8260B	1,2,4-Trichlorobenzene	ug/L	< 0.620	< 0.620
SW8260B	1,1,2,2-Tetrachloroethane	ug/L	< 0.300	< 0.300
SW8260B	1,2-Dibromo-3-chloropropane	ug/L	< 1.24	< 1.24
SW8260B	Methyl-t-butyl ether	ug/L	14.9	14.6
SW8260B	Tetrachloroethene	ug/L	< 0.620	< 0.620
SW8260B	Dibromochloromethane	ug/L	< 0.300	< 0.300
SW8260B	1,3-Dichloropropane	ug/L	< 0.240	< 0.240
SW8260B	1,2-Dibromoethane	ug/L	< 0.620	< 0.620
SW8260B	Carbon tetrachloride	ug/L	< 0.620	< 0.620
SW8260B	1,1,1,2-Tetrachloroethane	ug/L	< 0.300	< 0.300
SW8260B	Chloroform	ug/L	< 0.600	< 0.600
SW8260B	Bromobenzene	ug/L	< 0.620	< 0.620
SW8260B	1,2,3-Trichloropropane	ug/L	< 0.620	< 0.620
SW8260B	Chloromethane	ug/L	< 0.620	< 0.620
SW8260B	Bromomethane	ug/L	< 1.88	< 1.88
SW8260B	Bromochloromethane	ug/L	< 0.620	< 0.620

Table 5
Background Monitoring VOC Summary
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

			AS-MW-8	AS-MW-8 (Duplicate)
Method	Analyte	Units		
SW8260B	Vinyl chloride	ug/L	< 0.620	< 0.620
SW8260B	Dichlorodifluoromethane	ug/L	< 0.620	< 0.620
SW8260B	Chloroethane	ug/L	< 0.620	< 0.620
SW8260B	sec-Butylbenzene	ug/L	< 0.620	< 0.620
SW8260B	Bromodichloromethane	ug/L	< 0.300	< 0.300
SW8260B	1,1-Dichloroethene	ug/L	< 0.620	< 0.620
SW8260B	2-Butanone (MEK)	ug/L	< 6.20	< 6.20
SW8260B	Methylene chloride	ug/L	< 2.00	< 2.00
SW8260B	Trichlorofluoromethane	ug/L	< 0.620	< 0.620
SW8260B	P & M -Xylene	ug/L	< 1.24	< 1.24
SW8260B	Naphthalene	ug/L	< 1.24	< 1.24
SW8260B	o-Xylene	ug/L	< 0.620	< 0.620
SW8260B	Bromoform	ug/L	< 0.620	< 0.620
SW8260B	Xylenes (total)	ug/L	< 1.88	< 1.88
SW8260B	1,2,4-Trimethylbenzene	ug/L	< 0.620	< 0.620
SW8260B	tert-Butylbenzene	ug/L	< 0.620	< 0.620
SW8260B	1,1,1-Trichloroethane	ug/L	< 0.620	< 0.620
SW8260B	1,1-Dichloroethane	ug/L	< 0.620	< 0.620
SW8260B	2-Chlorotoluene	ug/L	< 0.620	< 0.620
SW8260B	Trichloroethene	ug/L	< 0.620	< 0.620
SW8260B	trans-1,2-Dichloroethene	ug/L	< 0.620	< 0.620
SW8260B	1,2-Dichlorobenzene	ug/L	< 0.620	< 0.620
SW8260B	2,2-Dichloropropane	ug/L	< 0.620	< 0.620
SW8260B	Hexachlorobutadiene	ug/L	< 0.620	< 0.620
SW8260B	Isopropylbenzene (Cumene)	ug/L	< 0.620	< 0.620
SW8260B	2-Hexanone	ug/L	< 6.20	< 6.20
SW8260B	1,2-Dichloropropane	ug/L	< 0.620	< 0.620
SW8260B	1,1-Dichloropropene	ug/L	< 0.620	< 0.620
SW8260B	1,1,2-Trichloroethane	ug/L	< 0.620	< 0.620
SW8260B	1,3-Dichlorobenzene	ug/L	< 0.620	< 0.620
SW8260B	1,2,3-Trichlorobenzene	ug/L	< 0.620	< 0.620

Notes:

EPA Environmental Protection Agency
µg/L micrograms per liter
mg/L milligrams per liter
JH Esimated result; biased high
B Result considered non-detect due to method blank detection

Table 6
Aesthetic Water Quality Monitoring
Air Sparge Pilot System
North Pole Refinery
Flint Hills Resources Alaska, LLC

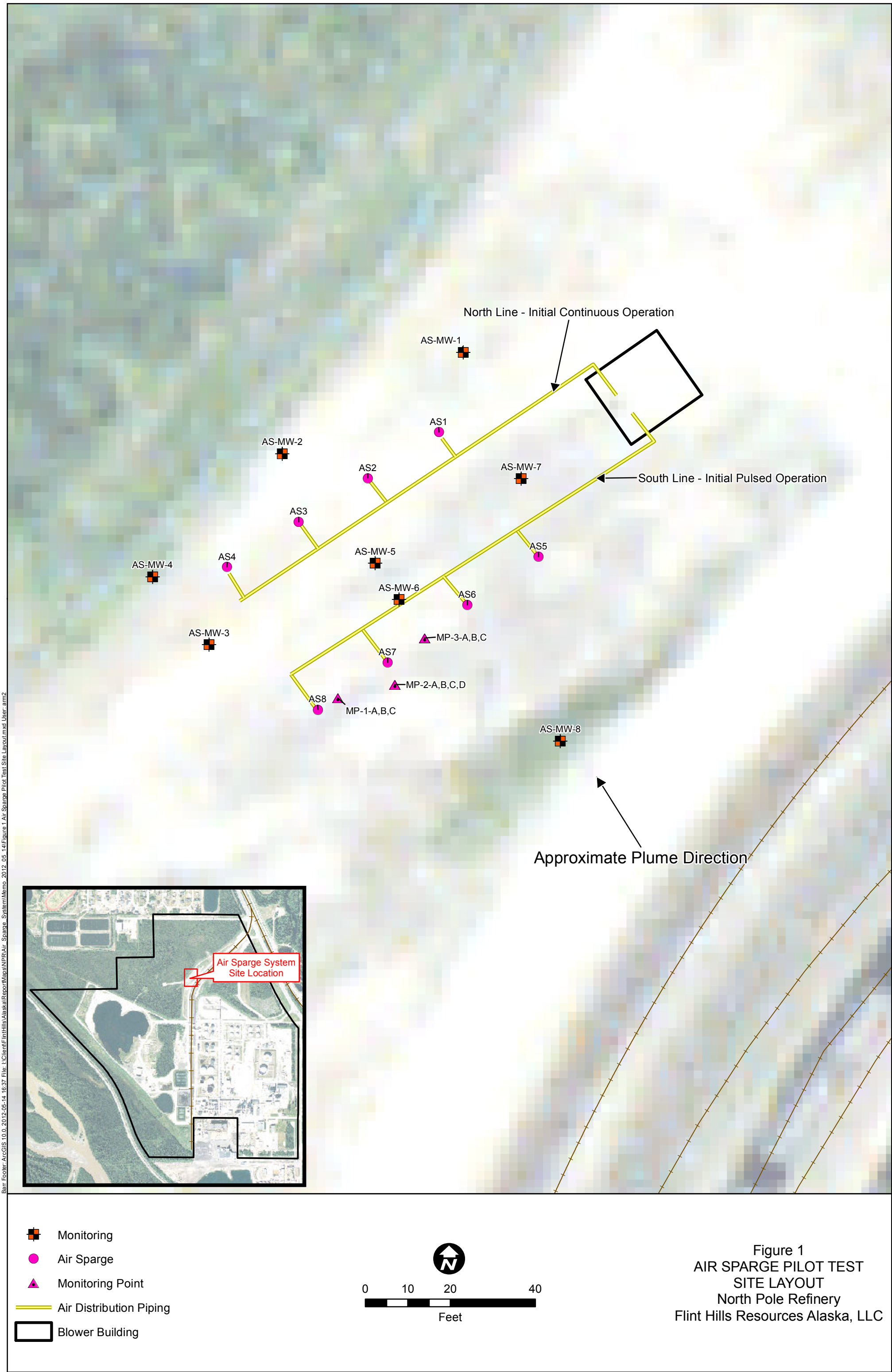
		AS-MW-2	AS-MW-8
Analyte	Units		
Total Organic Carbon	mg/L	3.64	6.38
Dissolved Iron	mg/L	<0.156	<0.156
Dissolved Manganese	mg/L	1.27	0.901
Total Kjeldahl Nitrogen	mg/L	0.710J	0.880J
Total Phosphorus	mg/L	<0.0117B*	<0.0144B*
Total Iron	mg/L	0.234J	0.168J
Total Manganese	mg/L	1.320	0.826
Total Copper	mg/L	0.0329	0.00615
Total Calcium	mg/L	42.9	48.6
Heterotrophic Plate Count	CFU/mL	<1	9
Color, Apparent	PCU	10.0	10.0
Odor (TON)	T.O.N.	<1.00	<1.00
Turbidity	NTU	3.73	2.39
Total Dissolved Solids	mg/L	209	238
Total Suspended Solids	mg/L	4.40	3.50
Alkalinity	mg/L	91.6	147
HCO ₃ Alkalinity	mg/L	91.6	147
CO ₃ Alkalinity	mg/L	<6.20	<6.20
OH Alkalinity	mg/L	<6.20	<6.20
pH	pH units	7.50	7.10
Sulfate	mg/L	63.9	26.3

Notes:

- mg/L milligrams per liter
- CFU/mL colony-forming units per milliliter
- PCU platinum-cobalt units
- T.O.N. threshold odor number
- NTU nephelometric turbidity units
- B* Analyte considered not detected at listed reporting level due to method-blank contamination

Figures

Barr Footer: ArcGIS 10.0, 2012-05-14 16:37 File: I:\Client\FlintHills\Alaska\Report\Maps\NPR\Air_Sparge_System\Memo_2012_05_14\Figure 1 Air Sparge Pilot Test Site Layout.mxd User: am2



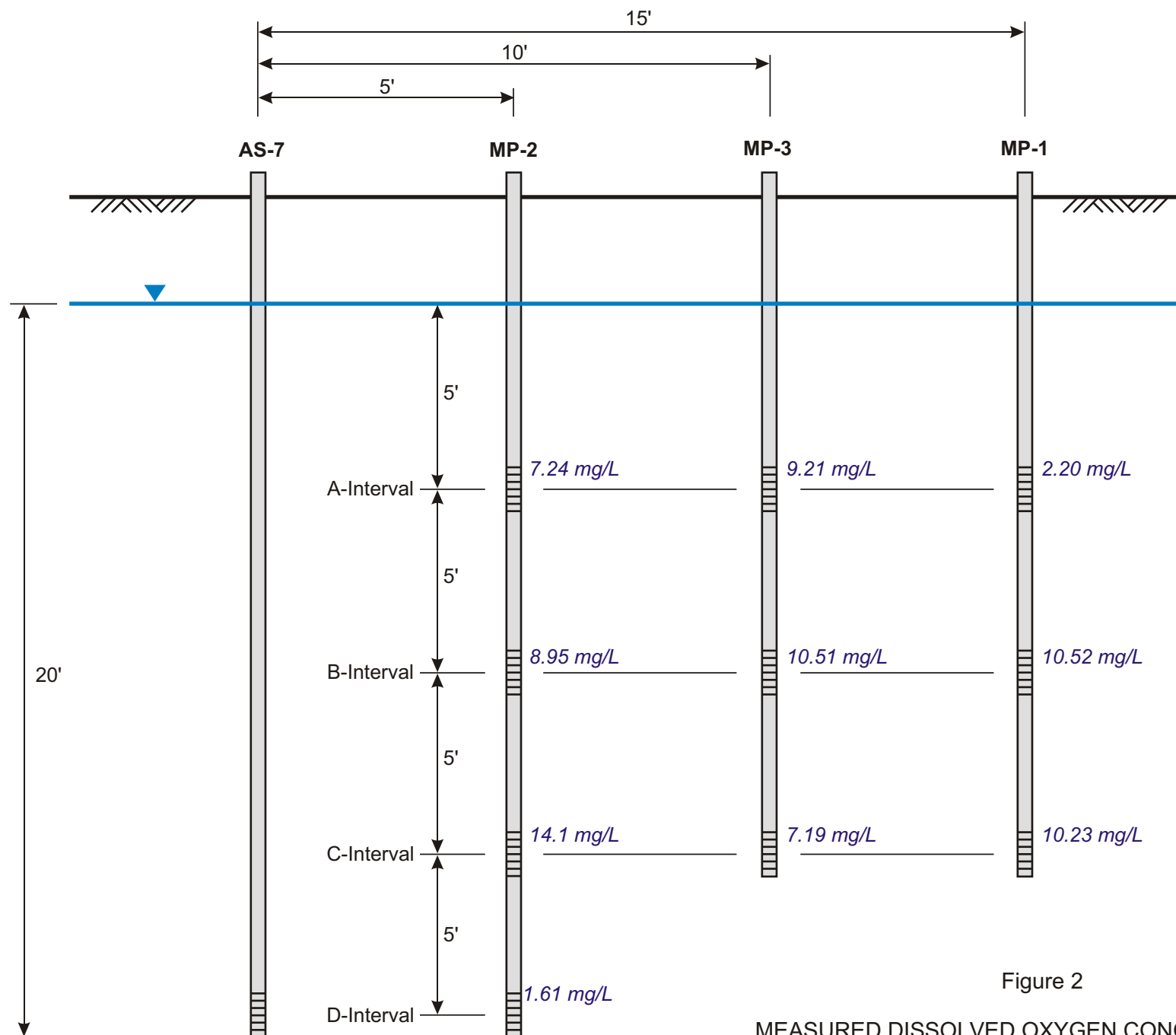


Figure 2

MEASURED DISSOLVED OXYGEN CONCENTRATIONS
BACKGROUND CONCENTRATIONS 0.1 TO 0.4 mg/L
North Pole Refinery
Flint Hills Resources Alaska, LLC

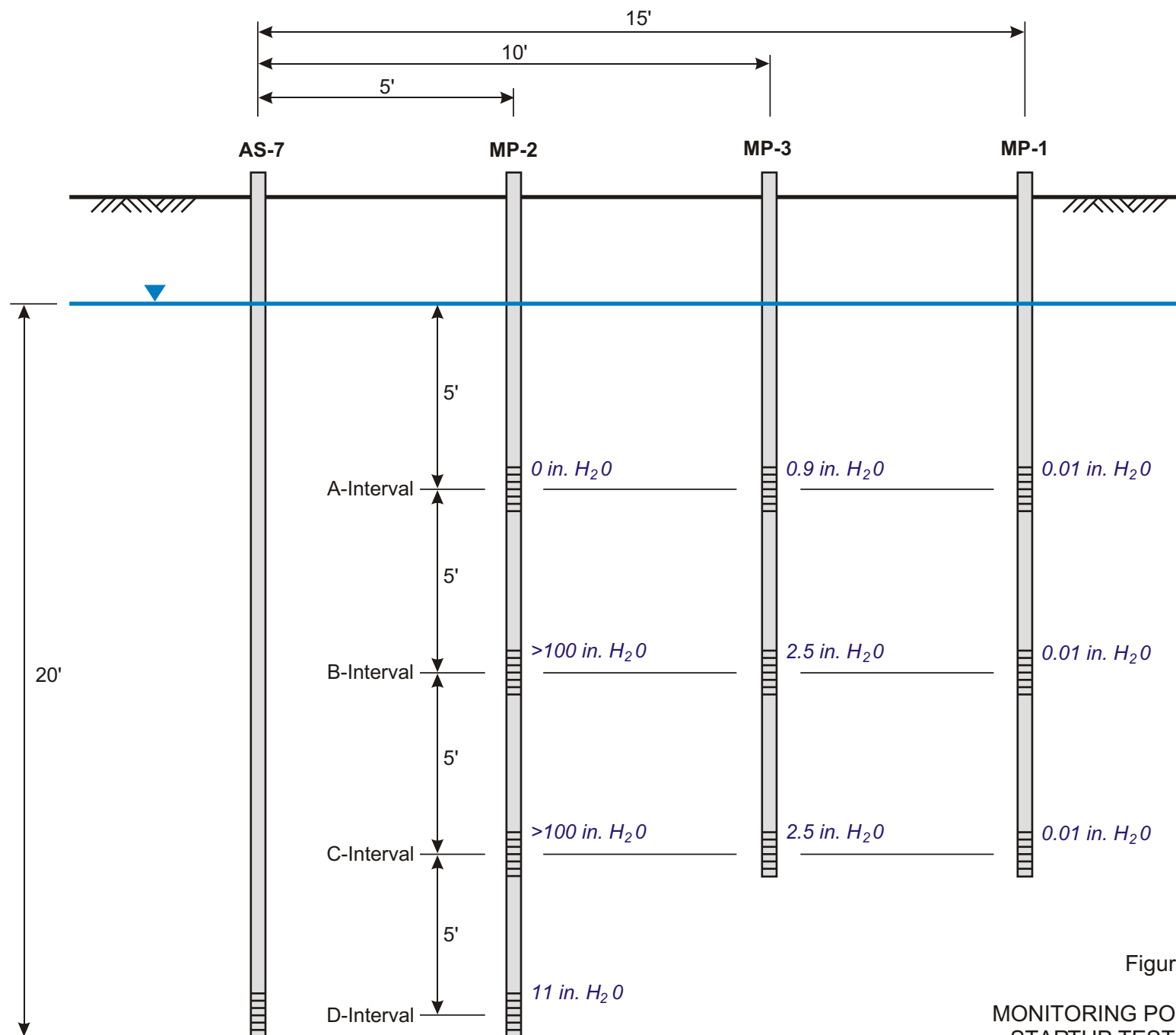
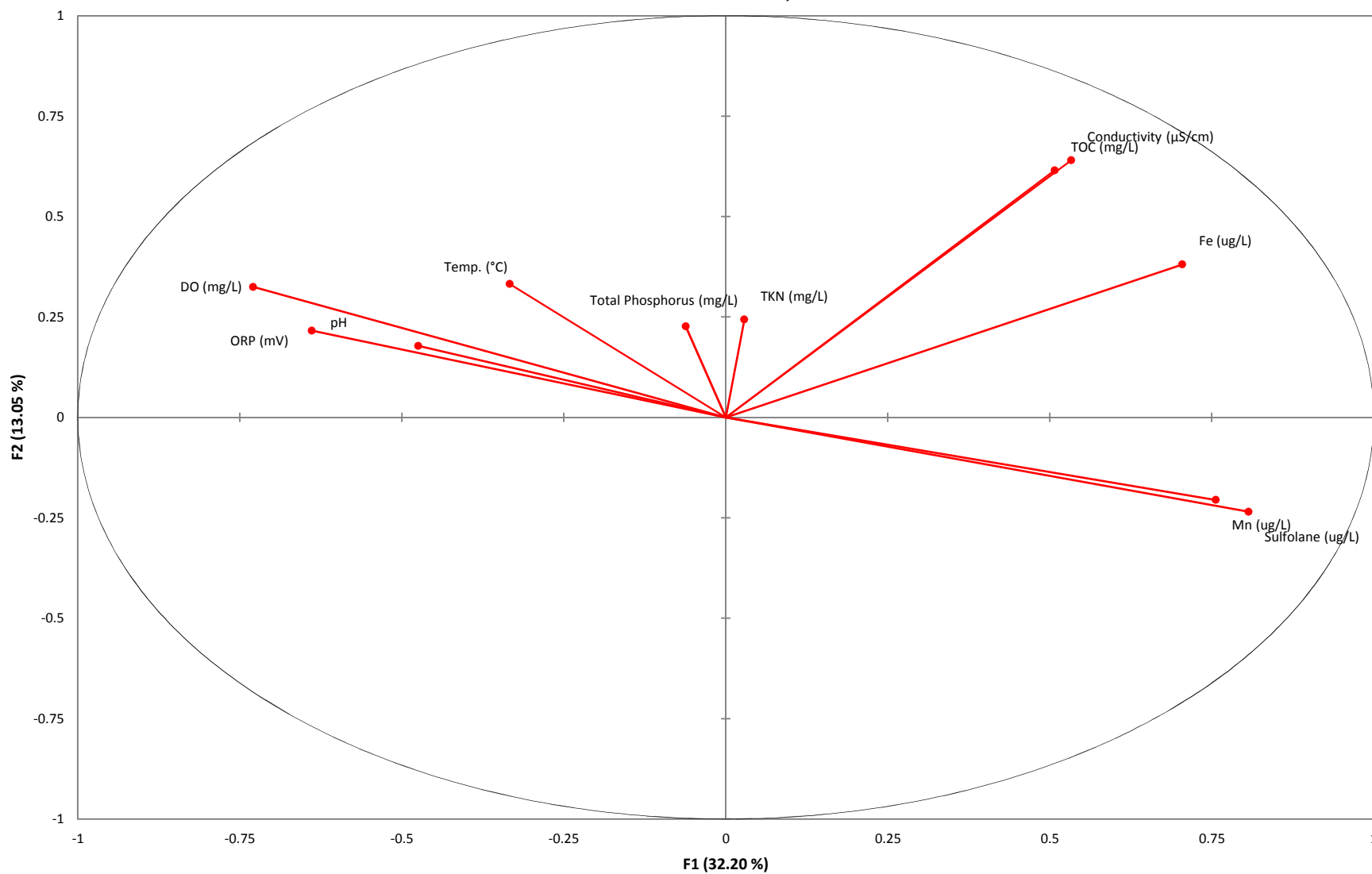


Figure 3

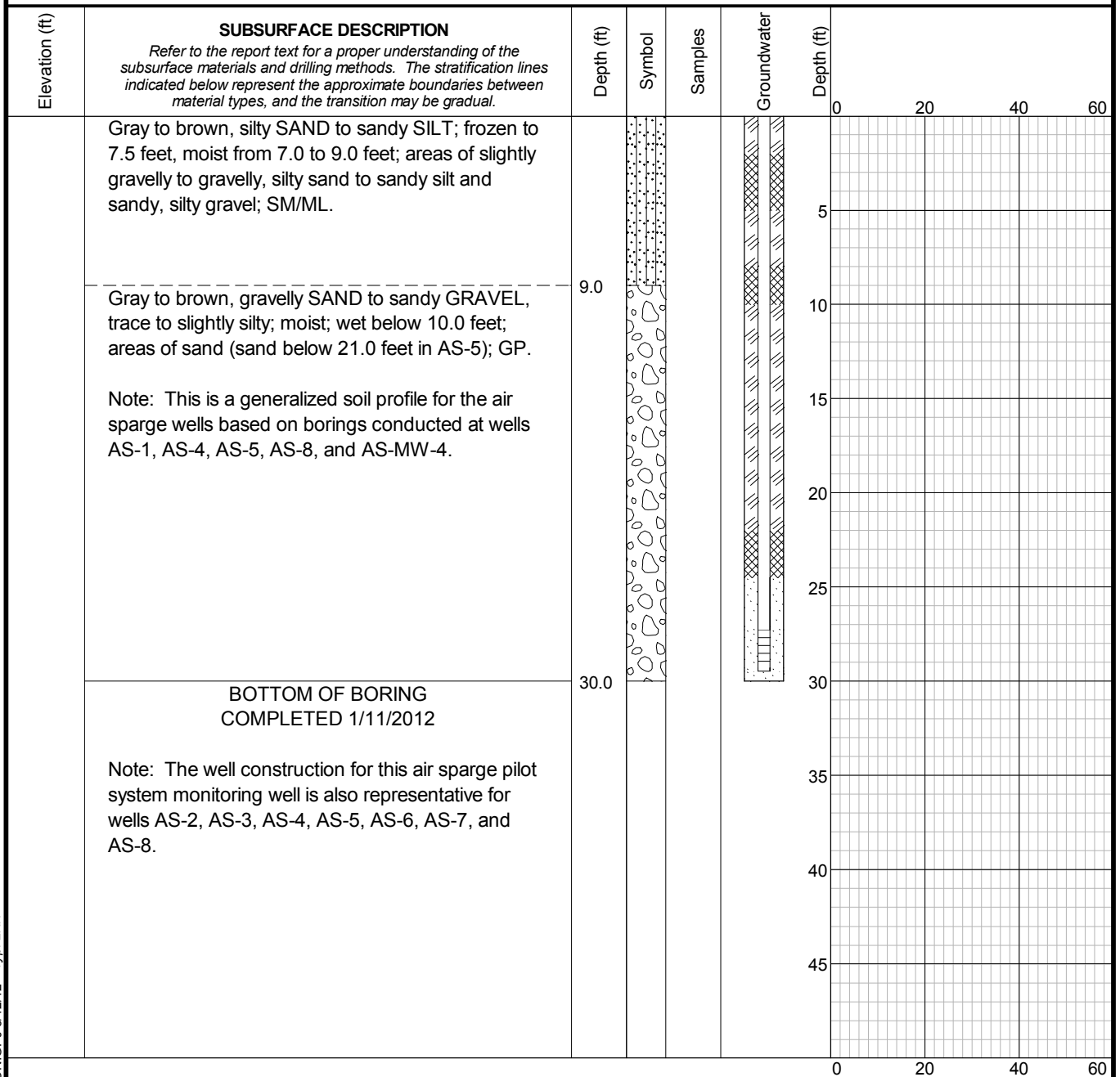
MONITORING POINT PRESSURE
STARTUP TESTING RESULTS
North Pole Refinery
Flint Hills Resources Alaska, LLC







Figure 4
Principal Component Plot
Air Sparge Pilot System-Baseline through Week 37
North Pole Refinery
Flint Hills Resources Alaska, LLC



Attachment A

Total Depth: 30 ft. Drilling Method: Hollow Stem Auger Hole Diam.: 8 in.
 Top Elevation: ~ Drilling Company: Homestead Rod Type: NWJ
 Vert. Datum: _____ Logger: _____ Drill Rig Equipment: Mobile Drill B-61 Hammer Type: _____
 Horiz. Datum: _____ Reviewer: _____ Other Comments: Air Sparge Pilot System



- LEGEND**
- * Sample Not Recovered
 -  Piezometer Screen and Sand Filter
 -  Bentonite-Cement Grout
 -  Bentonite Chips/Pellets
 -  Bentonite Grout
 -  % Fines (<0.075mm)
 -  % Water Content

- NOTES**
- Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
 - Groundwater level, if indicated above, is for the date specified and may vary.
 - USCS designation is based on visual-manual classification and selected lab testing.

Flint Hills Resources Alaska
 North Pole Refinery
 North Pole, Alaska

LOG OF BORING AS-1

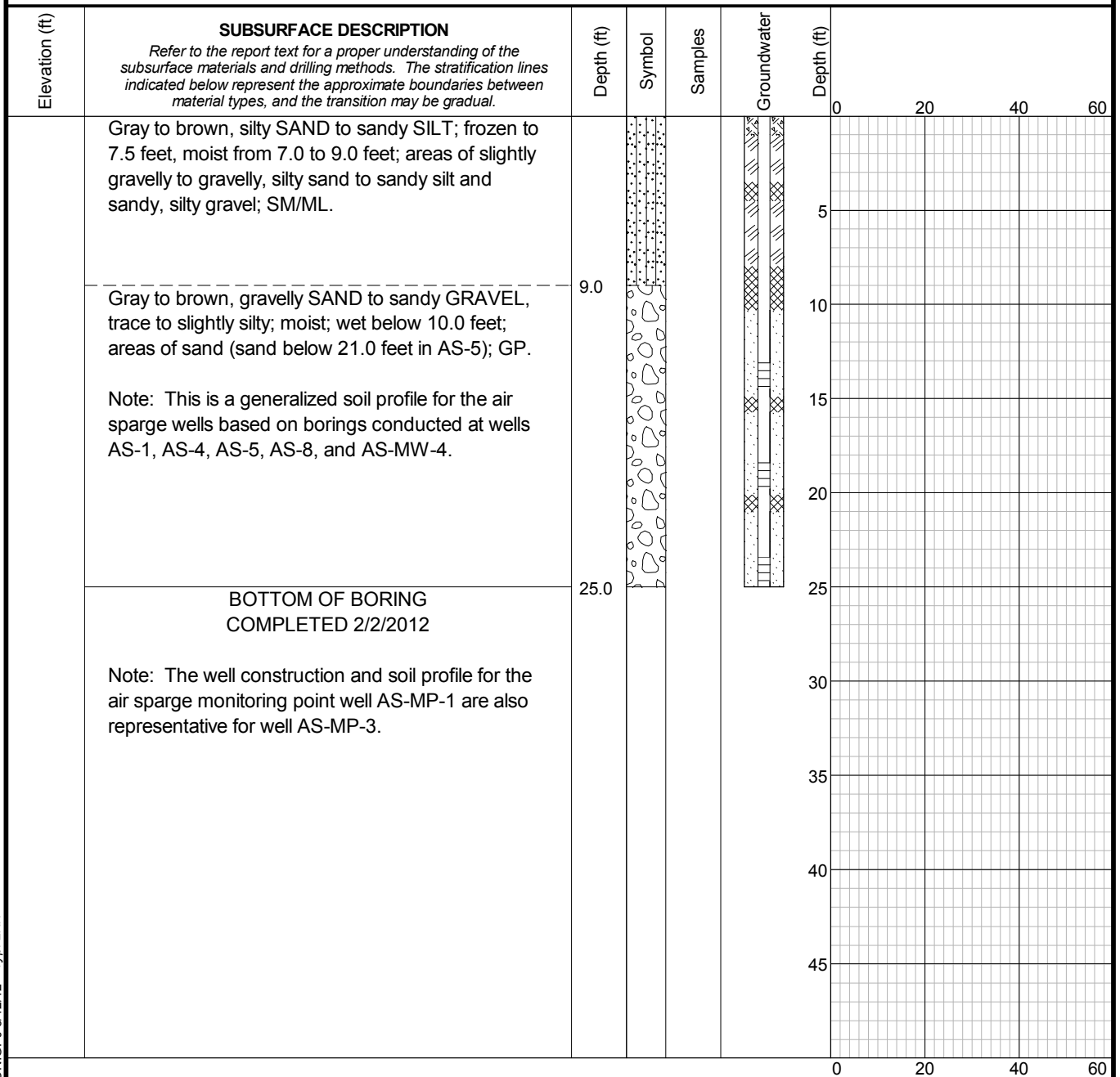
March 2012







31-1-11606-001

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 Geotechnical and Environmental Consultants

FIG.

Total Depth: 25 ft. Drilling Method: Hollow Stem Auger Hole Diam.: 8 in.
 Top Elevation: ~ Drilling Company: Homestead Rod Type: NWJ
 Vert. Datum: Logger: Drill Rig Equipment: Mobile Drill B-61 Hammer Type:
 Horiz. Datum: Reviewer: Other Comments: Air Sparge Pilot System



- LEGEND**
- * Sample Not Recovered
 -  Piezometer Screen and Sand Filter
 -  Bentonite-Cement Grout
 -  Bentonite Chips/Pellets
 -  Bentonite Grout
 -  % Fines (<0.075mm)
 -  % Water Content

- NOTES**
- Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
 - Groundwater level, if indicated above, is for the date specified and may vary.
 - USCS designation is based on visual-manual classification and selected lab testing.

Flint Hills Resources Alaska
 North Pole Refinery
 North Pole, Alaska

LOG OF BORING AS-MP-1

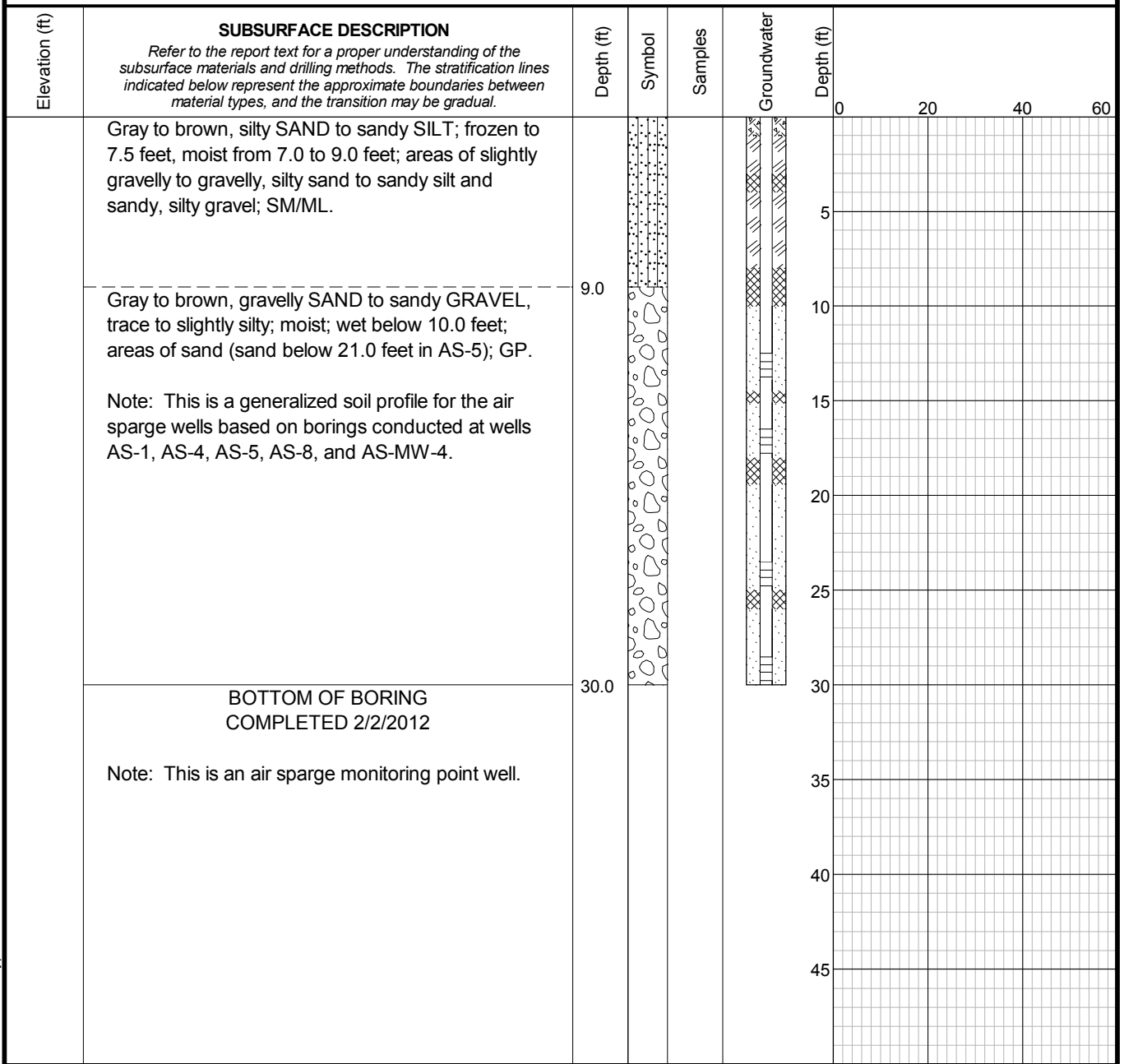
March 2012







31-1-11606-001

SHANNON & WILSON, INC.
 Geotechnical and Environmental Consultants

FIG.

Total Depth: 30 ft. Drilling Method: Hollow Stem Auger Hole Diam.: 8 in.
 Top Elevation: ~ Drilling Company: Homestead Rod Type: NWJ
 Vert. Datum: _____ Logger: _____ Drill Rig Equipment: Mobile Drill B-61 Hammer Type: _____
 Horiz. Datum: _____ Reviewer: _____ Other Comments: Air Sparge Pilot System



- LEGEND**
- * Sample Not Recovered
 -  Piezometer Screen and Sand Filter
 -  Bentonite-Cement Grout
 -  Bentonite Chips/Pellets
 -  Bentonite Grout
 -  % Fines (<0.075mm)
 -  % Water Content

- NOTES**
- Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
 - Groundwater level, if indicated above, is for the date specified and may vary.
 - USCS designation is based on visual-manual classification and selected lab testing.

Flint Hills Resources Alaska
 North Pole Refinery
 North Pole, Alaska

LOG OF BORING AS-MP-2

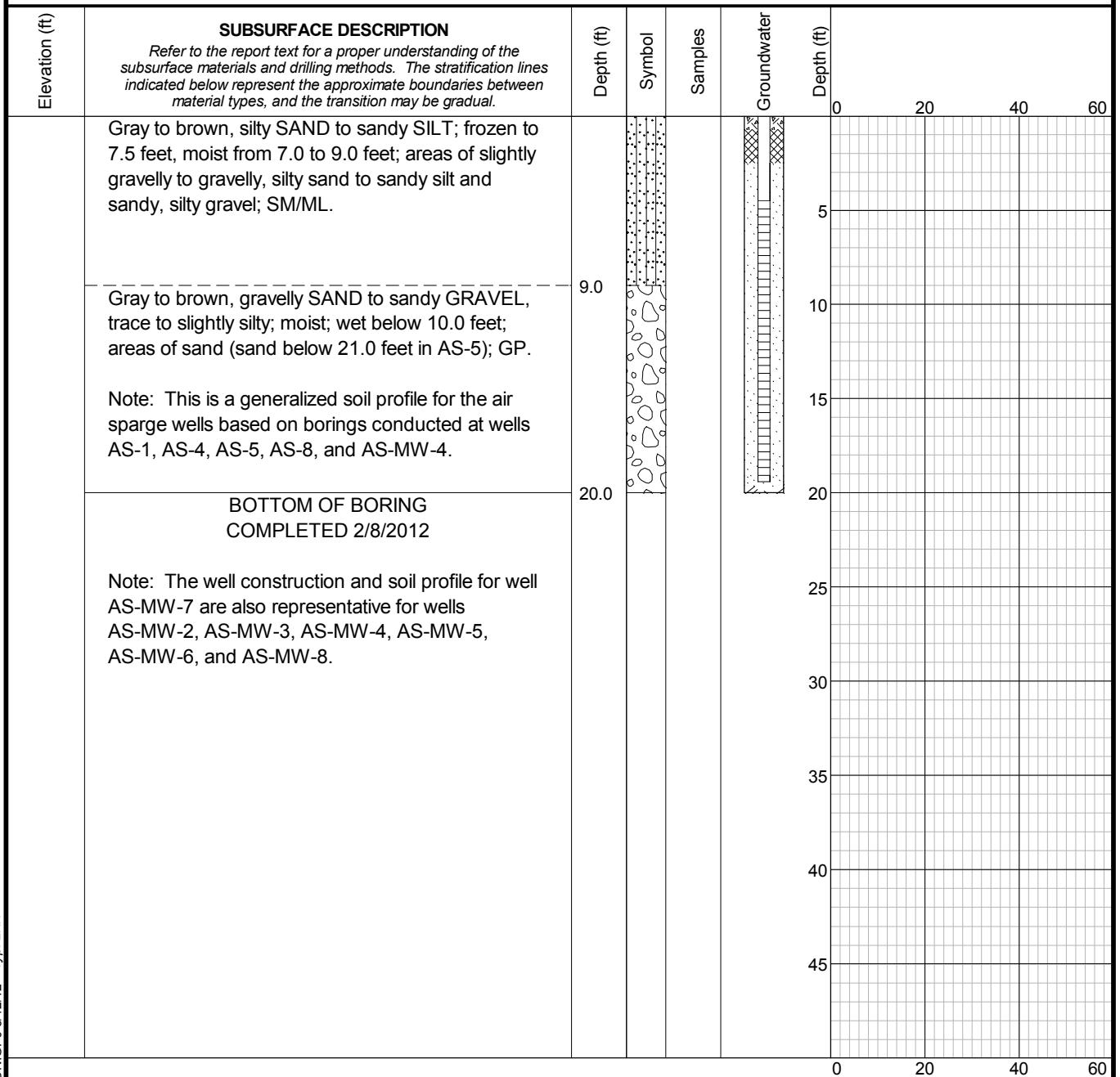
March 2012







31-1-11606-001

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FIG.

Total Depth: <u>20 ft.</u>	Drilling Method: <u>Hollow Stem Auger</u>	Hole Diam.: <u>8 in.</u>
Top Elevation: <u>~</u>	Drilling Company: <u>Homestead</u>	Rod Type: <u>NWJ</u>
Vert. Datum: _____	Drill Rig Equipment: <u>Mobile Drill B-61</u>	Hammer Type: _____
Horiz. Datum: _____	Other Comments: <u>Air Sparge Pilot System</u>	



- LEGEND**
- | | | |
|------------------------|---|--|
| * Sample Not Recovered |  Piezometer Screen and Sand Filter |  % Fines (<0.075mm) |
| |  Bentonite-Cement Grout |  % Water Content |
| |  Bentonite Chips/Pellets | |
| |  Bentonite Grout | |

- NOTES**
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
 2. Groundwater level, if indicated above, is for the date specified and may vary.
 3. USCS designation is based on visual-manual classification and selected lab testing.

Flint Hills Resources Alaska
North Pole Refinery
North Pole, Alaska

LOG OF BORING AS-MW-7

March 2012

31-1-11606-001

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Geotechnical and Environmental Consultants

FIG.

Attachment B



AIR/WATER CAPILLARY PRESSURE SUMMARY

(ASTM D6836; Centrifugal Method: air displacing water)

PETROLEUM SERVICES

ARCADIS

Core Lab File No: 412006EN

Project Name: North Pole Refinery
Project Number: B00819819.0005.00001

Sample Number	Sample Depth feet	Boring	Sample Orientation	Total Porosity %Vb	Bulk Density g/cc	Water Saturation, fraction pore volume												
						Capillary Pressure												
						psi	0.0	0.10	0.25	0.50	1.0	2.0	4.0	8.0	15.0	30.0	60.0	110.0
						cm	0.0	7	18	35	70	141	281	562	1055	2109	4219	7734
1	27.5-29.5	AS-7	H	37.3	1.70	1.00	1.000	0.792	0.696	0.597	0.478	0.301	0.200	0.143	0.118	0.094	0.076	



AIR/WATER CAPILLARY PRESSURE

(ASTM D6836; Centrifugal Method: air displacing water)

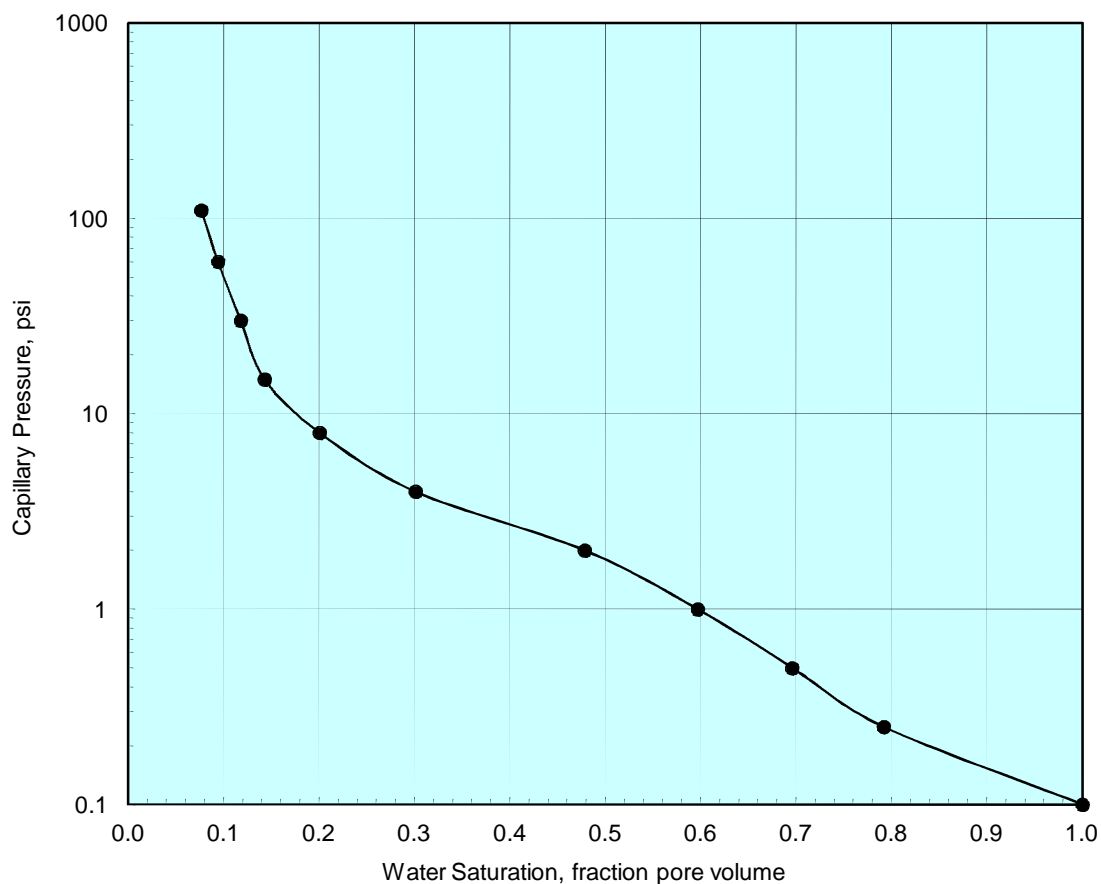
PETROLEUM SERVICES

ARCADIS

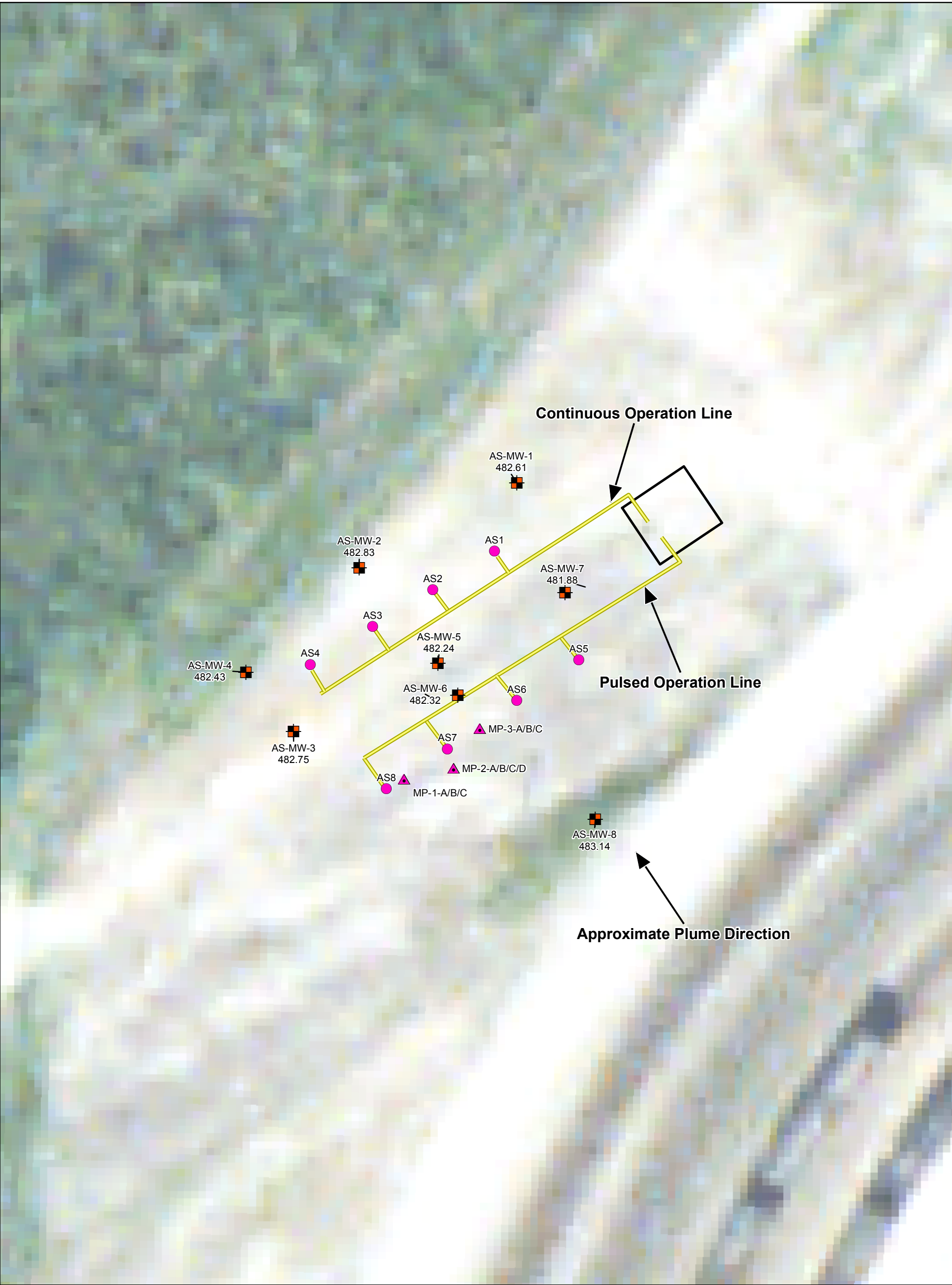
Core Lab File No: 412006EN

Project Name: North Pole Refinery
Project Number: B00819819.0005.00001

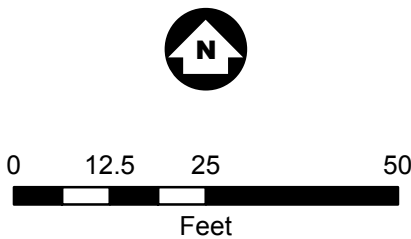
Sample Number	Sample Depth Interval, feet	Boring	Total Porosity, %Vb	Bulk Density, gm/cc	Capillary Pressure		Height Above Water Table, ft	Water Saturation, frac PV
					psi	cm water		
1	27.5-29.5	AS-7	37.3	1.70	0.000	0.0	0.000	1.000
					0.100	7.0	0.231	1.000
					0.250	17.6	0.579	0.792
					0.500	35.2	1.16	0.696
					1.00	70.3	2.31	0.597
					2.00	141	4.63	0.478
					4.00	281	9.26	0.301
					8.00	562	18.5	0.200
					15.0	1055	34.7	0.143
					30.0	2109	69.4	0.118
					60.0	4219	139	0.094
					110	7734	255	0.076



Attachment C

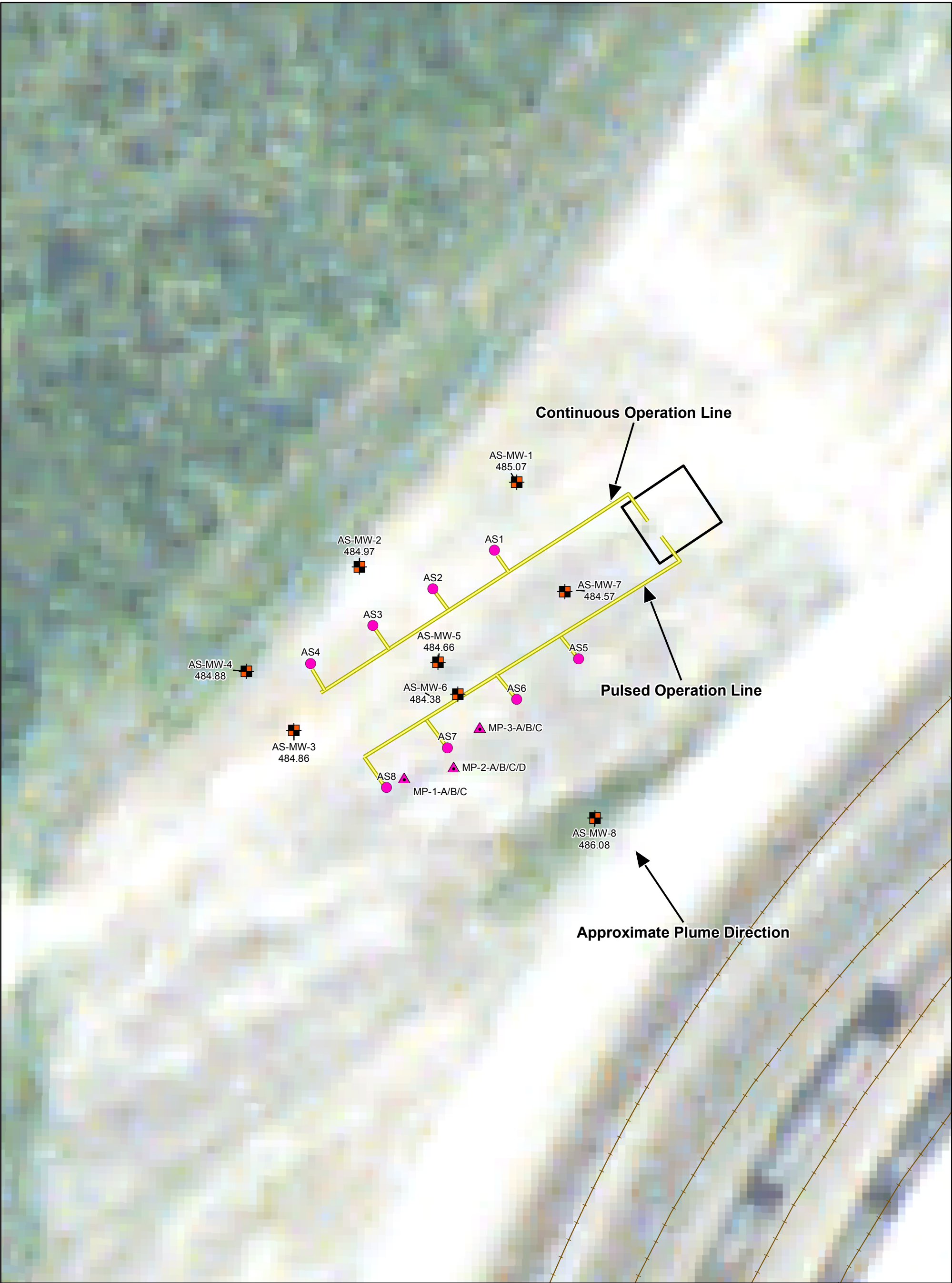


- Monitoring Well with Sulfolane Concentration
- Air Sparge Point
- Sparge Monitoring Point
- Air Distribution Piping
- Blower Building

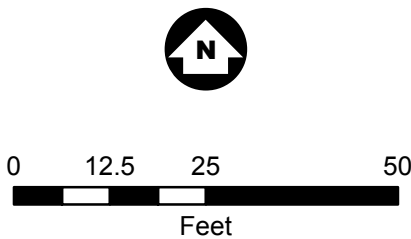


Attachment C

AIR SPARGE PILOT TEST
GROUNDWATER ELEVATION
Week 5 Event 4/11/2012
North Pole Refinery
Flint Hills Resources Alaska, LLC



- Monitoring Well with Sulfolane Concentration
- Air Sparge Point
- Sparge Monitoring Point
- Air Distribution Piping
- Blower Building



Attachment C

AIR SPARGE PILOT TEST
GROUNDWATER ELEVATION
Week 20 Event 7/27/12
North Pole Refinery
Flint Hills Resource Alaska, LLC